POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

Contents

36 Million Takes It 486
With the Editors 487
Business Deserves. Engineering—A Depression Cure. Scintillating Journalism.
Limiting Factors for High Steam Temperature. By Sabin Crocker and Harvey A. Wagner 488
Austin Cuts Power Costs. By Carroll L. Elliott and J. V. Edeskuty 491
Coal Handling—Storing and Reclaiming 494
Making New Boilers Out of Old Ones 495
Mechanism of Heat Transfer by Evaporation. By Allen G. Stimson 498
Modern Turbines. By L. E. Newman 502
Vertical Life Switchgear Simplifies Small Power Stations. By L. L. Mellers 506
Fuel and Operation Affect Diesel Deposits. By J. R. MacGregor and W. V. Hanley 509
Election Tubes—Principles and Applications. Part XXVIII By A. W. Kramer 512
Federal Power Developments in the West 516
Building Refrigeration Machines for Service. By Terry Mitchell 518
Boiler Erection. By Pulverizer Pete 520
Topics Talked About at Engineering Conventions 521
'Round About with Dick Morris 537
Dr. Johnstone on Sulphur Removal 538
Readers' Conference 539
New Equipment 542
News From the Field 545
For the Engineer's Library 547
Power Plant Construction News 548

Contents of back issues of Power Plant Engineering will be found in Industrial Arts Index on file in Public Libraries.

AUGUST
1938

Vol. XLII., No. 8

Published on the first of each month, copyright 1938 by the
Technical Publishing Co., 53 W. Jackson Blvd., Chicago.
New York Office, 171 Madison Ave.

EDITORIAL STAFF: ARTHUR L. RICE, Editorial Director R. E. TURNER, Editor.
A. W. KRAMER, Electrical Editor RICHARD H. MORRIS, Engineering Editor.

Subscription price. U. S. A. $2.00 a year; other countries, $3.50 a year. Single copy current issue, 25c; other countries, 35c. January issue, U. S. A., 50c; other countries, 60c. Back issues, single copy, U. S. A., 40c; other countries, 50c. January issue, U. S. A., 75c; other countries, 85c.

Member, Associated Business Papers, Audit Bureau of Circulations.

Photo, Bureau of Reclamation

36 MILLION TAKES IT

At ten o'clock in the morning on June 1, in Sacramento, California, a group of men assembled in a plainly appointed room to open the bids submitted for the construction of Shasta Dam, the second largest in the world—second only to Grand Coulee. It went for a scant thirty-six million dollars—$35,939,450 to be exact—to Pacific Contractors Incorporated of Los Angeles, a syndicate of 12 contracting firms incorporated for the purpose. Only two bids were submitted. The other was by the Shasta Construction Co. of San Francisco, a syndicate of 9 firms, their bid being $36,202,357. The difference between the bids was only $262,907, less than one per cent of the total, which on so large a job indicates close figuring and keen rivalry. In the photograph above, Walker R. Young, construction engineer of the Bureau of Reclamation in charge of the Central Valley project is shown reading the two bids to a large gathering of contractors and the public.

Thirty-six million dollars! A large sum in terms of ordinary experience—almost as much as a single certain young woman with a penchant for titled husbands could write a check for—and yet a mere bagatelle compared to the cost of even a single battleship.

The life of a battleship is about 25 years and during its lifetime is a constant source of expense; yet we appropriate one hundred and forty millions dollars for two battleships without batting an eye. In calling attention to this it is not our intention to argue the relative values of battleships and Shasta Dam; the ancient theologians used to argue about how many angels could stand on the point of a needle and they got nowhere, in fact none of them had ever seen an angel. It is interesting, however, to know that this dam which will be of inestimable value in the scheme of safeguarding the productivity of Central Valley, and with all its 5,610,000 cu. yd. of concrete, with all its 350,000 kilowatts of electric generating capacity, will cost just half of what we spend for a modern battleship which it is almost certain will never be used for the one particular purpose for which it is built.

The place of the Shasta Dam in the plan for the development of the Central Valley is that of a monitor on the Sacramento River, the principal water producer in interior California. The dam will regulate the flow of the river, making it possible to provide for the transportation of water into the San Joaquim Valley to supplement the irrigation supplies of large areas now faced with reversion to desert through exhaustion of the underground water on which they have depended. It will also serve to augment the stream flow in summer months and thus keep backed up in San Francisco Bay the salt water which now, from time to time, creeps upstream damaging crops in the low lying delta between Stockton and Suisum Bay.

A view of Shasta Damsite with other pictures of federal power projects is shown on page 516.

WITH THE EDITORS

Business Deserves?

"THE MAN who builds a factory (or a power plant) builds a temple; the man who works there worships there; and to each is due not scorn and blame but reverence and praise." Thus Calvin Coolidge worded his thoughts about business.

In these temples where each worker has been provided with $8000 worth of machinery and power equal to 5 horses are created the means for healthful, joyous living—food, furniture, clothing, games, automobiles—and the machinery for producing the essentials of modern life—water supply, light, heat, transportation.

For their service workers are paid the wherewithal to purchase the necessities and luxuries, which they require. Thus were paid during the years from 1930 to 1934 to the workers by the keepers of the temples over $18,000,000,000 more than the "royal industrial economists" received for the products, in wages whose purchasing power was twice that of workers' wages in England, three times that for Germany, five times that for Italy.

Churches, schools, hospitals, homes, highways, these are the products of and result from the temple activities. Best results depend upon coöperation, loyalty and faith among leaders and workers. For leaders and workers make up business.

Does business deserve scorn and the stirring of strife, or praise, confidence and aid to progress?

Engineering—A Depression Cure

THE HISTORY of social progress in America is based on the spreading of material advantages over large sections of the population. This has been accomplished largely through the genius of engineering and the development of marketing. Labor-saving machinery, mass production, transportation and selling have all contributed to lower prices. Low prices have made possible mass distribution which has raised the general living standards.

Social progress is not maintained at a steady rate. When a boom cycle is on the upswing, the public is complacent; social injustices are not so apparent; credit is inflated and prices go rapidly up.

Then comes the day of reckoning when prices reach the point where mass distribution shrinks. The credit pyramid topples and crashes. Hard times are upon us and social reforms receive a new impetus. Social reform is attempted in such overdoses that the nation develops social indigestion and the reaction again sets in.

Engineering is no cure-all for depressions. The whole closely woven economic structure is too complicated to be affected by any one human activity alone.

But right now conditions are such that engineering can, and has a solemn duty to, pull the country out of its present slump.

At present there are none of the economic maladjustments which brought about the crash of '29. Credit and money are plentiful, inventories are low, opportunity is fairly beating down our doors.

What is mainly needed to start the upward cycle (outside of the removal of certain artificial barriers to business, which is a subject of itself) is to bring about a gradual, orderly lowering of prices, which in turn will increase mass distribution and consumption, raise living standards and increase employment.

It is in this lowering of prices when the engineer steps into the picture as a major factor.

To be even more specific, the power plant engineer has today a particular opportunity and duty to analyze all factors affecting power costs; to plan and make definite recommendations as to new methods and new equipment needed to reduce power costs; and to sell those recommendations to the financial executive of his company.

It takes real courage to propose expenditures in these days when uncertainty is causing cash to be hoarded, but the well read, well informed engineer can clearly show the long run advantages of cutting the costs of power and thus reducing prices.

The manufacturers, through their sales engineers and their advertising in technical magazines are willing and anxious to help the engineer prepare his case.

Again we say, the power plant engineer holds in his hands a potent means of curing this present depression.

Scintillating Journalism

EVERY so often an intrepid newspaper man dips deep in the well of inspiration and produces a gem of purest ray serene to astound the world. One of these was a recent news service release dated, Washington, July 12. Starting out as a $47,000,000 WPA hydro development on the Big Muddy River in Illinois, the story switches over to steam, climbs the heights to mercury vapor and cuts the cost $21,000,000 by eliminating turbines, on to the stratosphere with mercury ionization and then flops back to a mere $5,000,000 hydro project.

"Power will be generated either through steam driven turbines or through steam ionization of mercury," says the dispatch, and "one point he (President Roosevelt) must decide is whether to install steam turbine engines or to have the mercury vapor method used to generate electricity without the use of turbines." Details were left up to President Roosevelt who took "all the papers with him on his transcontinental trip."

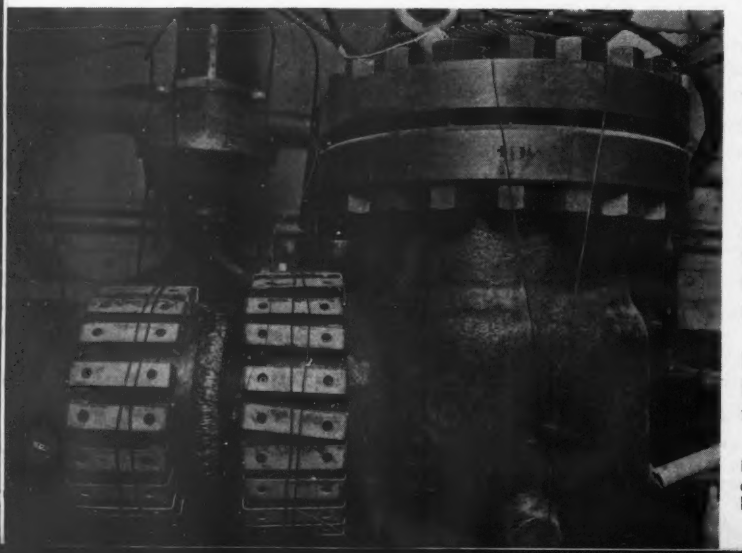
Perhaps this accounts for the President's waning interest in "political purging" as the trip progressed. The silver problem was child's play compared to the mercury problem facing the President, but just in case he does pull a few mercury ions out of the hat we are having a big 4 pt. head "Turbines Must Go" set up to occupy a prominent place in the hell box.

Limiting Factors for High Steam

Part I. Just why are present steam temperatures held to a maximum of 950 deg. F.? Is it because of superheater, piping or turbine parts? Can we expect commercial 1000 and 1100 deg. F. operation in the future? Why alloy steels? What of creep, corrosion, and oxidation? How do alloy steels influence piping costs? These questions are of immediate practical interest for the engineer is faced with the problem of utilizing to the best advantage materials available today. From a background of almost a decade of actual experience the authors consider the overall picture of high steam temperatures with particular attention to present limitations in the choice of piping materials.

EXAMINATION of the pressure-temperature conditions for power plant equipment installed within the past few years or now contemplated (Table I) shows that the steam temperatures at the superheater outlet do not exceed 950 deg. F. and usually are somewhat less. This is true despite the fact that an increase in steam temperature above 950 deg. F. would enable increased economy due both to the higher pressure-temperature conditions and to elimination of expensive and complicated reheat piping. The latter is sometimes employed to avoid high percentages of moisture in the turbine exhaust when using high pressures without correspondingly high temperatures. A moisture content of 12 to 15 per cent in the exhaust of a turbine, which is considered about the maximum permissible, permits a throttle pressure of about 1250-lb. per sq. in. at a steam temperature not in excess of 950 deg. F. Turbines are not the limiting factor in application of temperatures higher than 950 deg. F., since experience at Delray has demonstrated that they can be built successfully for 1000 deg. F., and, it is understood that turbine manufacturers are willing to quote on commercial size turbines for that temperature.

Use of higher steam temperatures at the present time is restricted by limitations of materials for both superheater tubes and main steam piping. The more important factors which must be considered in application of materials at high temperatures are: (1) strength; (2) oxidation and corrosion resistance; (3) weldability; (4) cost. A discussion of these items as they influence the selection of materials in power-plant operation at elevated temperatures follows.



Electric resistance type preheater on a 10-in. carbon-moly weld with the asbestos insulating blanket removed to show the preheater elements

As a means of comparing the relative usability of different steels, four have been selected to demonstrate these properties. These are: a silicon-killed carbon steel; a carbon-molybdenum steel containing about ½ per cent molybdenum; a 5 per cent chromium—½ per cent molybdenum steel; and a low-carbon 18 per cent chromium—8 per cent nickel alloy. Chemical compositions and physical properties of these alloys in the wrought form are shown in Tables II and III.

Probably the most important of the several factors is strength, since without adequate strength both at room and service temperatures, the material is of little value however favorable its corrosion and oxidation resistance, weldability, or cost. Particularly in pipe lines where flanged connections are used, room temperature physical properties of the material must be adequate. Success in securing a satisfactory initial gasket compression in a flanged joint is directly dependent on room temperature physical properties of the flange and bolt material, since sufficient compression must be exerted in bolting up the joint to secure a plastic deformation of the metal gasket without overstressing either flanges or bolts to the extent that a tight joint cannot be maintained. The short-time high-temperature strength also must be satisfactory since in warming up the line, additional stress is imposed on both flanges and bolts due to temperature difference between them. A flange material possessing high room-temperature physical properties obviously is likely to prove more successful in maintaining a tight joint, provided, adequate high-temperature properties also are assured.

Table I. Data on recently built power plants showing steam conditions at the superheater outlet, at the turbine throttle and the materials used in the main steam pipe and valves

STATION	SUPERHEATER Pressure lb./sq. in.	SUPERHEATER Temp. Deg. F.	THROTTLE Pressure lb./sq. in.	THROTTLE Temp. Deg. F.	MATERIALS Main Steam Pipe	MATERIALS Valves
Twin Branch*	2500	940	2400	940		
Essex	1475	950	1250	950	C-Mo	C-Mo
Windsor	1475	925	1265	925		
Springdale	1450	935	1235	925	C-Mo	C-Mo
West End	1450	910	1200	900	C-Mo	C-Mo
Logan	1425	925	1250	925		
Waterside	1400	900	1200	900	C-Mo	C-Mo
Ford—Rouge	1350	930	1215	910	C-Mo	C-Mo
Fisk	1275	910	1200	900	C-Mo	C-Mo
Delray	865	910	815	900	C-Mo	Cr-Ni-Mo
Columbia	775	910	665	900	C-Mo	C-Mo

*Employs reheat to 850 deg. at 415 lb. per sq. in.

TEMPERATURE SWINGS: Adequate strength must be secured for the maximum temperature involved, including upward swings beyond that normally set as the operating temperature. At elevated temperatures,

Temperatures

By SABIN CROCKER
Senior Engineering, Engineering Div.
and
HARVEY A. WAGNER
Engineer
The Detroit Edison Co., Detroit, Mich.

SABIN CROCKER, now Senior Engineer in the Engineering Division of The Detroit Edison Co., was formerly piping engineer in the Drafting and Surveying Bureau of the same company. He was graduated in 1915 from the University of Michigan with the degree of B.M.E. and, with the exception of 2 yr. (1917-1919) spent with the U. S. Naval Reserve Force and Emergency Fleet Corp. in engineering duties, has been employed since graduation by The Detroit Edison Co. He has taken an active part in ASA piping-standardization projects and in ASTM committees writing specifications for piping materials, particularly for high-temperature service.

HARVEY A. WAGNER, an engineer in the Engineering Division of The Detroit Edison Co. Was graduated from the University of Michigan in 1927 with the degree of B.S. in Mechanical Engineering. For the past 10 yr. he has been associated with Mr. Crocker in the committee activities, and is the author of several articles on various phases of piping standardization and design. Both Messrs. Crocker and Wagner enjoy national reputations in the piping field, and, with 10 yr. experience with the Detroit Edison Co. in the 1000-1100 deg. F. temperature range, are two of the few men in a position to speak authoritatively on the practical phases of this subject.

this need is emphasized by the rapid falling-off in strength for comparatively small increases in temperature. In the design of piping for the current extension of the Delray Plant of the Detroit Edison Co., for example, the normal temperature at the superheater outlet will be 910 deg. F., whereas the piping has been designed for a possible maximum of 925 deg. F. This distinction between what might be termed the "continuous" and "short time" temperatures for piping design permits consideration of short time bursting pressures on the basis of the higher temperature, while creep or plastic flow is predicated on the lower.

Materials used in the superheater are also subject to considerable temperature variations in addition to necessarily having a somewhat higher temperature than the steam within the tube. As a result of poor steam distribution in raising the boiler from a banked condition to full steam pressure and temperature, and, due to uneven steam distribution following load variations on the boiler, superheater tubes frequently are subjected to temperatures considerably above those obtaining in the main steam piping. Influence of such variations on the strength of material is important.

Tables II (above) and III (below). Chemical composition and physical properties of four pipe steels discussed in the article

CHEMICAL COMPOSITION

	Carbon Steel Grade B* ASTM A106	Carbon Molybdenum ASTM A206	5% Chrom.** Grade P 5a ASTM A158	18 Cr.-8 Ni.** Grade P 8a ASTM A158
Carbon, per cent	0.35 max	0.10-0.20	0.15 max	0.07 max
Manganese, per cent	0.75 min	0.30-0.60	0.50 max	0.20-0.70
Phosphorus, per cent	0.04	0.04	0.03	0.03
Sulfur, per cent	0.06	0.05	0.03	0.03
Silicon, per cent	0.15 min	0.10-0.50	0.50 max	0.75 max
Nickel, per cent				8.00-10.00
Chromium, per cent			4.00-6.00	17.0-20.0
Molybdenum, per cent		0.45-0.65	0.45-0.65	

PHYSICAL PROPERTIES

Tensile strength, lb. per sq. in.	62,000	55,000	65,000	80,000
Yield point, lb. per sq. in.	35,000	30,000	35,000	30,000
Elongation in 2 in., %	20***	30	33	60

*Modified analysis.
**Physical properties for these grades are suggested values higher than those given as minimums in ASTM A158-37T.
***Transverse tension test.

ALLOWABLE STRESSES: In selecting safe working stresses at high temperature, it should be recognized that some parts must retain their dimensions within a small tolerance in order to maintain necessary clearances, such as in turbines and to some extent in valves. For most piping, however, the primary consideration is that the deformation, due to the accumulated effect of creep, should not continue to the point where fracure or serious change in shape occurs. This permits selection of somewhat higher values of allowable stress for steam pipe than would be countenanced for some parts of turbines, but, it should be kept in mind, that it is frequently impossible to predict the exact stress a part may have to withstand.

Fig. 1 shows allowable stresses for wrought pipe materials at various temperatures which might be assigned to the four alloys chosen for discussion, on the basis of their creep strength assuming a creep rate of one per cent in 100,000 hr., the usual basis of design for power-plant work. A creep rate of this magnitude corresponds to an elongation of one-ten-millionths of the length per hour, which is the order of the measurements on tensile specimens taken in laboratories in determining creep strength. The expected elongation of one per cent after 100,000 hr. operation is extrapolated from tests usually not longer than 5000 hr. duration, with many not longer than 500 to 1000 hr. Materials are being used at elevated temperatures on the assumption that these tests predict with reasonable accuracy the expected useful life of the material normally considered to be from 15 to 20 yr. for power plants. Not until many years service has been secured will it be known to what extent these predictions are justified.

Curves for carbon steel and carbon-molybdenum steel are based on values which have been tentatively assigned by the Ferrous Subgroup of the ASME Boiler Code Committee as published in the February, 1938, issue of Mechanical Engineering. The curve shown for medium-carbon steel considers a silicon-killed steel as distinguished from the usual run of product which is aluminum killed. The low-carbon grades of steel for pipe are usually aluminum killed. Creep tests have demonstrated, however, that the silicon-killed variety possesses sufficiently better high-temperature strength to warrant its use for service at elevated temperatures.

It may be observed for carbon-molybdenum steel, that, over a range of 900 to 950 deg. F., the allowable stress falls from 10,000 to 8000 lb. per sq. in., so at 950 deg. F., this material is allowed only 80 per cent of its strength at 900 deg. F. For a rise of another 25 deg. F., the value drops to 65 per cent of its strength at 900 deg. F. It is thus evident that in using carbon-bolybdenum material, continuous temperatures exceeding 950 deg. F. are not desirable due to the very rapid falling off in the strength of the material. Even short upward swings above the nominal "continuous" temperature should be given careful consideration in design where such swings take the temperature above 950 deg. F. This also points to the need for securing a uniformly high grade product. For this reason, ferritic banding of rolled steel as in pipe, dendrites in steel castings insufficiently broken by heat treatment, alloy segregations producing instability in creep, and laminations which reduce the effective thickness of metal, are all to be avoided if an excessive creep is not desired.

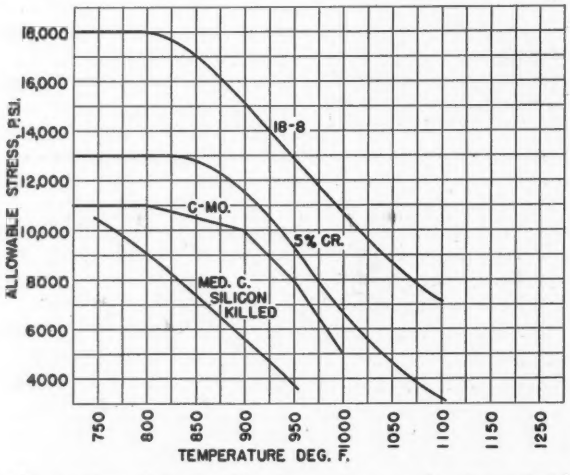


Fig. 1. Suggested allowable stresses for wrought pipe materials (ferritic steels in normalized and drawn condition) based on a creep rate of 1 per cent per 100,000 hr., the design standard for piping in power plant practice. The two lower curves, for C-Mo and Med. C steels, are based on values proposed by the Ferrous Subcommittee of the A.S.M.E. Boiler Code Committee

RATINGS OF FITTINGS: The superior load-carrying ability of carbon-molybdenum steel over carbon steel at temperatures between 850 and 950 deg. F. has been considered adequate to justify assignment of considerably higher pressure-temperature ratings to flanges and fittings and indirectly to valves when made of cast carbon-molybdenum alloy steel. The primary pressure ratings of carbon-steel flanges and flanged fittings at 750 deg. F. are based on material having a 70,000 lb. per sq. in. tensile strength and 36,000 lb. per sq. in. yield point at room temperature. Carbon-molybdenum castings are based on a 70,000 tensile, 45,000 lb. per sq. in. yield material, but are assigned the same ratings at 900 deg. F. as carbon steel at 750 deg. F. This contemplates the standard facings such as plain raised face, tongue and groove, male and female, etcetera, where the tightness of the joint is more or less dependent on securing a high gasket compression without unduly distorting the flanges. Since it is claimed tightness can be maintained with the ring joint, without stressing the bolts so highly, primary ratings for carbon-molybdenum ring joints have been assigned for 950 deg. F, which are the same as for carbon steel raised face joints at 750 deg. F. Considerable experience with the ring joint, particularly in the oil industry, seems to indicate these ratings are warranted. Ratings for carbon-steel fittings and carbon-molybdenum fittings, both with standard facings, are shown in Tables IV and V.

(To be concluded)

Table IV. Ratings for carbon steel flanged fittings and companion flanges with standard facings covered by American Standard B 16 e, including male and female, tongue and groove, plain raised face and Van Stone. All pressures are in pounds per square inch gage

WATER, STEAM AND OIL SERVICE PRESSURE RATINGS AT TEMPERATURES OF 750 DEG. F. AND BELOW

Primary Service Pressure Ratings	150	300	400	600	900	1500	2500*
Service Temperature, Deg. F.	Maximum, Non-Shock, Service Pressure Ratings						
100	230	500	670	1000	1500	2500	4170
150	220	480	640	960	1440	2400	4000
200	210	465	620	930	1395	2325	3875
250	200	450	600	900	1350	2250	3750
300	190	435	580	870	1305	2175	3625
350	180	420	560	840	1260	2100	3500
400	170	405	540	810	1215	2025	3375
450	160	390	520	780	1170	1950	3250
500	150*	375	500	750	1125	1875	3125
550	140	360	480	720	1080	1800	3000
600	130	345	460	690	1035	1725	2875
650	120	330	440	660	990	1650	2750
700	110	315	420	630	945	1575	2625
750	100	300*	400*	600*	900*	1500*	2500*

*Primary service pressure ratings.

STEAM SERVICE PRESSURE RATINGS AT TEMPERATURES ABOVE 750 DEG. F.

Primary Service Pressure Rating	150	300	400	600	900	1500	2500
Service Temperature, Deg. F.	Maximum Steam Service Pressure Ratings						
800	85	250	335	500	750	1250	2085
850	70	200	270	400	600	1000	1670

Table V. Proposed adjusted ratings for American Steel flange standards when made of carbon-molybdenum steel[1, 2] with standard facings covered by American Standard B 16 e, including male and female, tongue and groove, plain raised face and Van Stone. These ratings, for water, steam and oil, are in pounds per square inch gage

OIL SERVICE PRESSURE RATINGS AT TEMPERATURES ABOVE 750 DEG. F.

Primary Service Pressure Rating	150	300	400	600	900	1500	2500
Service Temperature, Deg. F.	Maximum Service Pressure Ratings						
800	92	275	370	550	830	1380	2300
850	82	245	330	490	740	1230	2050
900	70	210	280	420	630	1050	1750
950	55	165	220	330	495	825	1375
1000	40	120	160	240	360	600	1000

Primary Service Pressure Ratings	300	400	600	900	1500	2500
Service Temperatures, Deg. F.	Maximum, Non-Shock, Service Pressure Ratings					
100	600	800	1200	1800	3000	5000
150	590	775	1180	1770	2950	4905
200	580	750	1160	1740	2900	4810
250	560	725	1120	1680	2800	4645
300	540	700	1080	1620	2700	4480
350	520	675	1040	1560	2600	4315
400	500	650	1000	1500	2500	4150
450	480	625	960	1440	2400	3985
500	460	600	920	1380	2300	3820
550	440	575	880	1320	2200	3655
600	420	550	840	1260	2100	3490
650	400	525	800	1200	2000	3325
700	380	500	760	1140	1900	3160
750	360	475	720	1080	1800	2995
800	340	450	680	1020	1700	2830
850	320	425	640	960	1600	2665
900	300*	400*	600*	900*	1500*	2500*
950	265	350	530	795	1325	2205
1000	190	250	380	570	950	1580

*Primary service pressure ratings.

[1]Carbon-molybdenum alloy steel castings, Grade C1, and forgings, Grade F1 (ASTM Specifications A157-36 and A182-36) serve as the fundamental basis for alloy steel ratings. Other alloys with superior qualities may be given appropriate ratings.

[2]For temperature above 950 deg. F. Grades C1 and F1 for steam service should be given consideration as to scaling due to oxidation.

Austin Cuts Power Costs

$405,000 five-year development and modernization program of the municipal utilities of Austin, Minn., saves over $160,000 annually in operating costs

CARROLL L. ELLIOTT,
Superintendent
Board of W. E. G. & P. Comm.
Austin, Minn., and

JOSEPH V. EDESKUTY,*
Helmick, Edeskuty & Lutz
Minneapolis, Minn.

FOR MORE than 40 yr. the history of the municipal utilities of the city of Austin, Minn., has been one of outstanding success and continual growth. This is due in no small measure to the long and meritorious service of a non-partisan commission of five members which was formed in 1903 after the adoption of a new charter. This commission, appointed by the mayor, is in complete control of the city's utilities and the retiring members of this board have usually been reappointed. Losses, in almost every case, have been due to retirement through ill health, the last member of the original commission serving till 1934. Members of the present board have served for various periods dating back to 1922.

This commission appoints a full time secretary and superintendent who is in full charge of the operation and management of the utilities. The staff consists of a superintendent, two assistant engineers and an operating crew of 25. Five of these men are graduates of the various engineering colleges of the University of Minnesota and six men have service records of 25 yr. or over. The office force consists of a secretary and office manager, four stenographers and billers and two meter readers.

In 1897 a municipal water supply was organized and in 1900 the light plant was taken over from a private company and consolidated with the water works. In 1927 a one-pipe central steam heating system was installed to supply a portion of the business section and in 1935 the properties of the private gas company were purchased. Manufacture of gas was, for the time being, abandoned and natural gas, purchased from the Northern Natural Gas Co., is now retailed to the consumers.

Austin has grown rapidly and in the last decade the number of electric customers has about doubled. A total consumption of 1,083,000 kw-hr. in 1910 was doubled in 1920 and again in 1930. By 1936 it had again doubled and in 1937 reached a total of approximately 12,500,000 kw-hr.

*Engineering work for this modernization program was handled by Ralph D. Thomas & Associates, Minneapolis, Minn., with whom Joseph V. Edeskuty, the project engineer, was formerly connected.

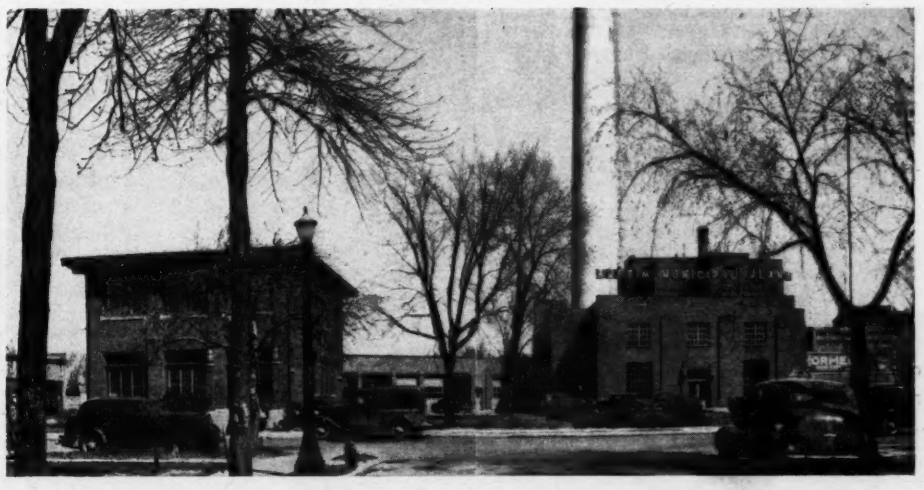


Fig. 1. Power plant and office building of the municipal utilities at Austin, Minn. The Hormel Packing plant, visible at the extreme right of the photograph, is on the far side of the Red Cedar River. This is Austin's major industry and a large power customer

This increase in the last 6 yr. explains the inadequacy of turbine and boiler room equipment installed in the years 1927 to 1929. Equipment of that same type, to handle the increased load, would have cost approximately $260,000, exclusive of PWA grants. It was felt, however, that the larger load justified more efficient equipment and in 1932 a program of expansion was worked out to take care of increased load in the most economical manner and include provision for future expansion required by the growth of the community.

Besides the natural development of water and gas mains, transmission lines, heating mains, etc., this program was carried out in steps as outlined in Table I. It was brought to a successful conclusion in 1937 at a net cost of $405,465.61, which was paid for entirely out of earnings, leaving the plant entirely free of bonded indebtedness. Each step of the program is explained in greater detail further on.

Rate Reductions Made Possible

Operating savings, made possible by the more efficient equipment involving an additional expenditure of approximately $145,000, made possible a series of rate reductions. The last of these went into effect on March 1, 1938. This schedule, shown in Table II, gives a direct comparison with rates in effect when the new program was started. Based on the 1937 load, the 1938 schedule will show a saving to the consumer, over the 1932 schedule, of $168,065.43, a direct cost comparison of the two schedules being shown by Columns 3 and 4 of Table III.

Contributing factors to lower operating costs are:

a. Lower water rates of the electric generating equipment.

b. Reduced amount of live steam discharged to the heating system, due to the greater bleeding capacity of the new turbine and the off peak load of the Hormel Packing Plant. In 1932-33 approximately 11,234,000 lb. of live steam was supplied to the heating system out of a total quantity of 45,500,000 lb. In 1937-38, out of a total quantity of 75,256,000 lb. only 1,928,000 lb. was live steam. This quantity could have been reduced materially as approximately 750,000 lb. of live steam was used in order to keep the pressure reducing valve regulators in operating condition.

c. Feedwater is now maintained at zero hardness, at the proper temperature for chemical reaction and conditioning, and for the prevention of caustic embrittlement. Periods between boiler washing have been considerably extended.

Table I. An outline of the 5 year Modernization Program (excluding the natural development of water, gas and heating mains and transmission lines) for the Municipal Utilities of Austin, Minn. The costs given include approximately 5 per cent for engineering fees

A.	New concrete chimney and breeching, 1932-33	$16,518.08
B.	Motor driven city water pumps, 1933	8,168.57
C.	Submarine cable connection to George A. Hormel Packing Plant, 1933 (Included in transmission system costs)	
D.	Water proofing reservoir lid, 1933	10,880.07
E.	New warehouse and garage, 1933-34	32,422.45
F.	New turbo-generator unit and auxiliary equipment, 1934-35	165,368.92
	a. 3500 kw. turbo-generator and auxiliaries.	
	b. Remodeling of the water treatment apparatus.	
	c. New three phase bus structure and Scott connected 2500 kv-a. transformer for gradually converting the present 2 phase to a 3 phase system.	
	d. Interdepartmental telephone system for despatching emergency calls and regular business.	
G.	New steam generating unit with auxiliary equipment, 1936-37	214,825.76
H.	Tunnel and gas valve house	15,153.00
	Total	483,336.85
	Less Government PWA Grants for D, E and F	57,871.24
	Net expenditure	$405,465.61

Table II. A comparison of the rate schedules in effect when the program was started in 1932 with the new rate schedules placed in effect March 1, 1938

	1932 Schedule	1938 Schedule
Minimum bill per meter per month	$1.00	$1.00
Residence rate	First 15 kw-hr. 8¢ /kw-hr. Next 15 " 7¢ /kw-hr. " 170 " 5¢ /kw-hr. All excess 4¢ /kw-hr.	First 25 kw-hr. 5¢ /kw-hr. Next 25 " 4¢ /kw-hr. " 200 " 2¢ /kw-hr. All excess 1½¢ /kw-hr.
For first 50 kw-hr.	$3.25	$2.25
Commercial rate	First 15 kw-hr. 8¢ /kw-hr. Next 100 " 7¢ /kw-hr. " 200 " 5¢ /kw-hr. All excess 4¢ /kw-hr.	First 50 kw-hr. 5¢ /kw-hr. Next 250 " 3¢ /kw-hr. " 3700 " 2¢ /kw-hr. All excess 1½¢ /kw-hr.
For first 4000 kw-hr.	$165.60	$84.00
Excess	4¢ per kw-hr.	1½¢ per kw-hr.
Average sale price per M lb. of steam	93.55¢	66.31¢

d. The overall boiler efficiency has been increased from 65 to 84 per cent.

e. The firing equipment now permits the use of either natural gas or cheap coals.

f. Stoker, furnace and boiler upkeep costs have been reduced.

This entire modernization was carried out without interruption of service and the plant is now efficient and thoroughly modern in every department. The program was preceded by a complete study of the steam and electric growth extending over the life of the plant and the future load in the period from 1935 to 1955 was estimated. These projected load curves, shown by Fig. 2, have proved to be conservative as indicated by the actual electric load, shown by the dotted line in the lower left hand corner.

When the modernization program was adopted in 1932, the power plant equipment consisted of two 812 hp. 300 lb., 650 deg. F. Combustion Engineering, bent tube boilers with a maximum steaming capacity of 50,000 lb. per hr. each. They were fired by American Engineering Co. Taylor 8 retort, 25 tuyere, single steam dump underfeed stokers. Both forced and induced draft fans were motor driven and a temporary steel chimney, which replaced a brick chimney destroyed by the cyclone in 1928, was in service. The auxiliary equipment included a hot process, lime and soda water softener.

Electric generating equipment consisted of three units, generating 2 phase, 60 cycle, 2300 v. electric current. The bus structure was located in the basement and the switchboard in a recess in the wall on the turbine room floor. Two steam driven city water supply pumps were located in the turbine room basement.

One of the generating units was a 2000 kw. bleeder type unit operating at 275 lb. ga. and 650 deg. F., set over a jet condenser. It was equipped with a direct-connected exciter. Up to the capacity of the machine, steam was bled for the central heating system and feedwater heating. Additional require-

PRODUCTION AND REVENUE		COL. I 1932-33	COL. II 1937-38	COL. III 1932 Schedule	COL. IV 1938 Schedule
1. Generated,	kw-hr.	5,910,745	12,263,200		
2. Used in plant,	" "	967,950	809,844		
3. Distrib. loss,	" "	709,160	1,024,832		
4. Sold,	" "	4,233,635	10,428,524		
a. Resid.light,	" "	1,173,078	2,063,843	2,063,843	2,063,843
Revenue,		$84,639.00	$102,770.97	$148,906.27	$87,713.33
Cooking,	" "	579,213	893,492	893,492	893,492
Revenue,		$18,729.00	$23,891.47	$28,895.53	$23,230.79
b. Comm. light,	" "	836,000	1,670,073	1,670,073	1,670,073
Revenue,		$45,200.00	$67,592.93	$90,300.85	$50,686.71
c. Comm. power,	" "	608,344	1,128,191	1,128,191	1,128,191
Revenue,		$22,079.00	$31,306.51	$40,942.05	$30,461.16
d. Rural lights,	" "	130,792	326,548	326,548	326,548
Revenue,		$11,664.00	$18,396.97	$29,121.55	$17,473.58
e. City & St.Lgt.,	" "	871,968	1,174,604	1,174,604	1,174,604
Revenue,		$18,725.00	$21,248.00	$25,223.93	$21,248.00
f. Hormel Co.,	" "		2,722,710	2,722,710	2,722,710
Revenue,			$21,620.33	$21,620.33	$21,620.33
g. City W. Pumps,	" "	37,300	449,063	41,000	449,063
Revenue,		$373.00	$6,735.96	$615.00	$6,735.96
5. Steam made M lb., F. & A.		232,294	266,313		
Steam to heat main, M lb.		45,500	75,266		
Live steam to heat main, M lb.		11,234	1,928		
Steam sold, M lb.		34,950	51,619	51,619	51,619
Revenue,		$32,696.00	$34,288.72	$48,289.57	$33,552.35
6. Total gal. water pumped		372,683,000	409,993,392	409,993,392	409,993,392
steam used M lb.		48,371		53,213	
Cost of steam (50.5¢ per M + 15% Overhead)		$24,427.35		$26,872.56	
Total Revenue		$258,432.35	$327,791.86	$460,787.64	$292,722.21
Annual Sav. to Customers				$168,065.43	

Table III. Summary of production and revenue. Columns III and IV based on 1937-38 consumption give a direct comparison of the cost under the 1932 schedule and under the present 1938 schedule. Following past practice, expansion of facilities to take care of the increased load would have cost approximately $260,000. A program of modernization using more efficient equipment cost $405,465.61. This additional expenditure of $145,000 made possible savings of $168,065.43 as calculated above by subtracting Column IV from Column III

ments were supplied by the high pressure main through reducing valves and desuperheater. Two additional units, one 1200 kw. and one 750 kw., were built for 200 lb. pressure, saturated steam and both exhausted to jet condensers. In addition to the generating equipment there was one motor driven and one steam engine driven exciter set.

The first major item in the program was the construction of a reinforced concrete chimney of sufficient capacity to serve the old boilers up to their full capacity without the use of induced draft fans and, in addition, take care of the requirements of one new unit including the air preheater up to a capacity of 40,000 lb. per hr., without the use of induced draft fans. This stack has a shaft of 264 ft. above the hexagonal base plate. The top inside diameter is 12 ft. and the top elevation 260 ft. above the boiler room floor. The base is 4 ft. thick and has a short diameter of 26 ft. 6 in. The bottom of the breeching opening is 35 ft. 6 in. above the floor and a reinforced concrete slab on a slope of 45 ft. with the lowest elevation 12 ft. above the boiler room floor forms a soot chamber. The bottom of the shaft is filled and provided with a 6 in. reinforced concrete floor at the boiler room level. The space between the floor and the soot chamber slab is connected with the new warehouse by a steel door and forms a storage for pipe fittings and miscellaneous materials for line construction.

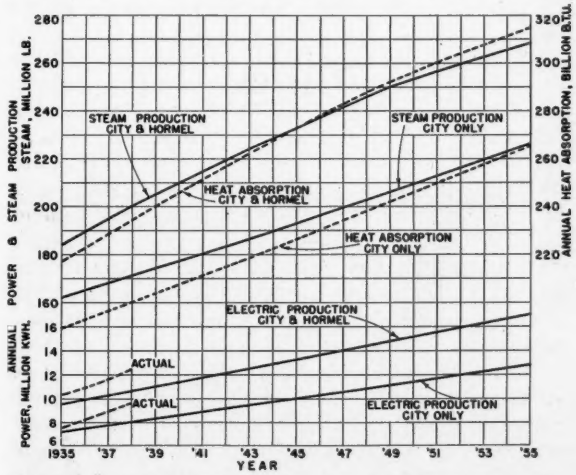

STEAM PRODUCTION CITY & HORMEL
STEAM PRODUCTION CITY ONLY
HEAT ABSORPTION CITY & HORMEL
HEAT ABSORPTION CITY ONLY
ELECTRIC PRODUCTION CITY & HORMEL
ACTUAL
ACTUAL
ELECTRIC PRODUCTION CITY ONLY
ANNUAL POWER & STEAM PRODUCTION STEAM, MILLION LB.
ANNUAL HEAT ABSORPTION, BILLION B.T.U.
POWER, MILLION KWH.
YEAR
1935 '37 '39 '41 '43 '45 '47 '49 '51 '53 '55

Fig. 2. From 1905 to 1933 the electric peak increased from 200 to 1700 kw. at a constant rate of about 55 kw. per year. There was little change during 1932 but from 1933 to the end of 1937 the peak had climbed to over 2600 kw. for the city alone plus an additional 800 kw. from the Hormel load taken on in 1933. The electric output of 1,083,000 kw-hr. in 1910 doubled every decade to 1930, had doubled again by 1936 and amounted to 12,500,000 kw-hr. in 1937. The above curves show the electric and steam loads projected to 1955 from studies made in 1934. The heavy dotted lines in the lower left hand corner show the actual electric output during the past three years. Steam is used in a central heating system extending over a large part of the city

The presence of water bearing sand to a considerable depth made special precautions necessary in the design of the foundations. The base plate is connected to 6 reinforced concrete caissons, sunk to bedrock by the open method and employing 8 ft. courses of lagging, the individual caissons being from 29 to 36 ft. deep below the bottom of the base plate. The chimney is equipped with safety ladder, necessary lighting conductors and is floodlighted at night.

Water Works Pumps and Reservoir

Projects B, D and E of Table I are indirectly connected with the power plant modernization. In 1933 the steam driven city water pumps in the turbine room basement were replaced by two 1200 g.p.m. Worthington motor driven centrifugal pumps and in the same year extensive repairs were carried out on the Sargent Springs Reservoir lid.

This reservoir, about 260 ft. long, with an average width of 120 ft., contains one major and several smaller springs with a total capacity of 2 m.g.d. of excellent drinking water at a temperature of 38 deg. F. The underside of the lid contained large areas where the concrete was badly deteriorated and spalled with a considerable number of stalactites, due to the

action of condensation at low outside temperatures. After tests had determined the structural soundness of the slab the following procedure was resorted to in order to prevent further deterioration.

A 1 in. layer of Nuwood, built up of ½ in. boards cemented together with asphalt was laid on an asphalt base. Over this were laid 3 plies of asphalt saturated felt, and, covered with a 30 lb. asbestos felt and coated with hot asphalt. After completion of the insulation and roofing the underside of the slab was sprayed with emulsified asphaltum. At the present time, the lid is in excellent condition.

Expansion of the utility made it necessary to provide space for storage and for housing the fleet of trucks, repair department, meter testing, etc. Space to the west of the boiler room between the turbine room and the new chimney was utilized for this purpose, and a two story warehouse with basement was built. In the basement is oil storage and racks for pipe and conduit storage. On the first floor are wash rooms, repair shop, office and storerooms and loading platforms for trucks on the inside and for railroad cars on the outside. On the second floor are the testing departments for electric, gas, water and steam meters, general space and recreation room with a vestibule, coatroom and kitchenette. An automatic 5 t. elevator serves the basement and two floors. The old coal shed adjoining this space was transformed into a modern garage approximately 115 by 27 ft. with a greasing pit, wash rack, gasoline pump and equipped with 6 overhead folding doors and a service door. A room for line tools is also provided for in this space.

Steps C and Fc are closely related and were made necessary by a contract, made in 1933, to supply 3 ph., 60 cycle current to the Geo. A. Hormel Co., one of the major industries of the state of Minnesota. This plant is located on the opposite shore of the Red Cedar River and is visible in the right hand side of the power plant in Fig. 1. To complete this contract a submarine cable 1075 ft. long and weighing 11.5 was laid across the river to connect the electric distribution system of the municipal plant with the packing plant. This cable has three 500,000 circular mill conductors and 3 pairs of No. 12 wires for telephones and for relay protection. At that time all of the generating equipment was 2 phase, so a 2500 kv-a. General Electric Scott connected transformer was installed at the municipal plant. This transformer is also used for gradually converting the present 2 phase distribution system into a 3 phase system.

EDITOR'S NOTE: Details of the turbine and boiler room changes with tests and cost calculations will appear in two subsequent articles by the same authors. The first will be Turbine Changes at Austin. The second, Austin's High Pressure Boiler, is of especial interest because of performance data on the water cooled stoker.

COAL HANDLING Storage and Reclaiming

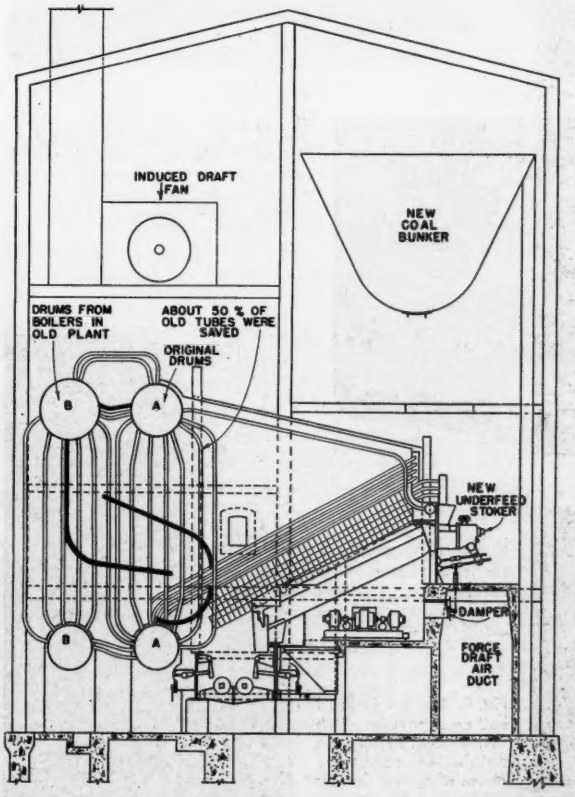
Extending the piling area of steam coal at the Bethlehem Plant of the Bethlehem Steel Co. was recently accomplished by utilizing a 15 t. tractor and bulldozer as shown at the right. With the aid of a platform the bulldozer is also used to reload the coal for consumption as shown above. The company states that the bulldozer, long standard equipment in earth moving, does the job at about one fourth of what it would cost to do the work with a traveling crane.

While the bulldozer has been chiefly utilized in handling barley-size anthracite, the Bethlehem Plant's main source of steam coal, experience has indicated that it can be applied to piling coking-size bituminous coal with equal efficiency. Under average conditions the bulldozer is capable of piling or loading barley-size anthracite at the rate of about 80 t. an hr.

Making New Boilers Out of Old Ones

Two Groups of Boilers in Two Old Boiler Plants at the Castanea Paper Co. used in Making One New Group for use in Modernized Plant. Two New Turbines also installed.

THE REVAMPING of an old power plant, never an easy task, is especially difficult when it is necessary to maintain power service while the construction operations are in progress, and under such conditions often calls for a degree of skill and resourcefulness quite unrelated to new construction. This was particularly true of the revamping job shown in the accompanying illustrations—that involved in modernizing the power generating facilities at the Castanea Paper Co. at Johnsonburg, Pa. The work here involved the rebuilding of five old boilers and the installation of two new bleeder turbogenerators coincident with the removal of an old turbine and a 1000-hp. engine.



Section through boiler house showing the construction of the boilers and their arrangement in the building

There were formerly two boiler plants at this mill, both old but one so obsolete that it had to be abandoned. The better of the two plants contained five two-drum Erie City boilers which were in good condition. The older plant also had Erie City boilers.

In the modernizing program, the five boilers at the better of the two plants were rebuilt into the form shown in Fig. 1. The front drums of the new boilers are the old drums of old units, unchanged. These were backed up by the drums from the 4 boilers in the older plant and by one set from an old boiler in another plant at Lockhaven, Pa., where this company has another paper mill. Thus, as shown by the cross section, the rebuilt boilers are 4 drum boilers, with water walls at the front and side walls of the stoker fired furnaces. In the rebuilding process which was all done by the Erie City Iron Works, about 50 per cent of the old tubes were also saved.

The reconstruction also included the installation of new Taylor stokers, forced and induced draft fans, a new coal bunker and coal conveying equipment and new boiler instruments.

Because of the headroom demanded by the new overhead coal bunkers and the induced draft fans which are installed above the boilers, it was necessary to raise the roof in the manner shown in the photographs.

As will be noted, the space available was extremely limited and the clearances small, a condition which made the work more difficult. Before the new arrangement was placed in operation, coal was stored in a bin at one end of the boiler house. This was fed by an inclined bucket conveyor and coal from the bin was distributed to the boilers by a larry.

With the new arrangement, the coal bunker extends the entire length of the boiler room and it is supplied by an overhead horizontal belt conveyor. During construction, after the new coal bunker had been installed, the horizontal belt was first put in place and fed by the old bucket conveyor. Thus the new conveyor was used while a new inclined feeder belt was installed. The old bucket conveyor is still used as a standby.

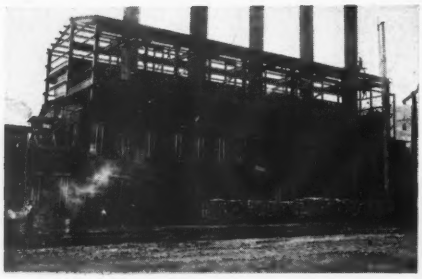


Fig. 1. Exterior view of the boiler house, showing how the roof was raised to accommodate the new coal bunker and the induced draft fans

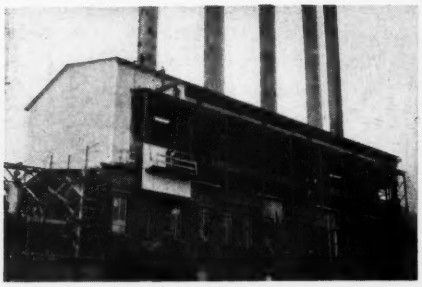


Fig. 2. Here the new upper portion has been practically completed. This shows the bays built to house the breechings

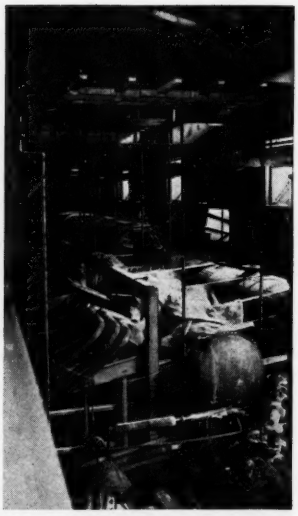


Fig. 3. A view inside during construction showing close clearances and difficulty of working. This shows the new rear drums being put in place

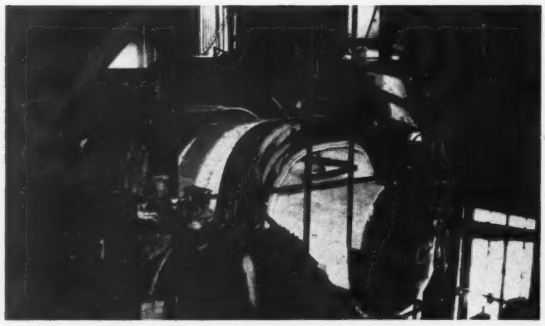


Fig. 4. A close up at one of the new rear drums being lagged. Fig. 5 at the right is a view just above this point on the new induced draft fan floor, showing one of the forced draft fans in place. Note coal bunker in shadow at left

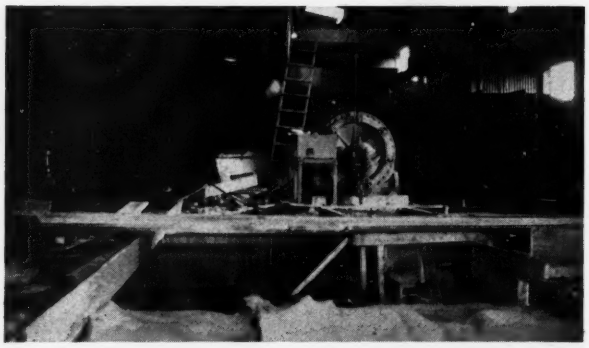


Fig. 6. The new coal bunker under construction

Fig. 7. Left. Inside the furnace during construction showing the water walls at the side of the furnace. The new stokers are in place underneath the wooden scaffolding

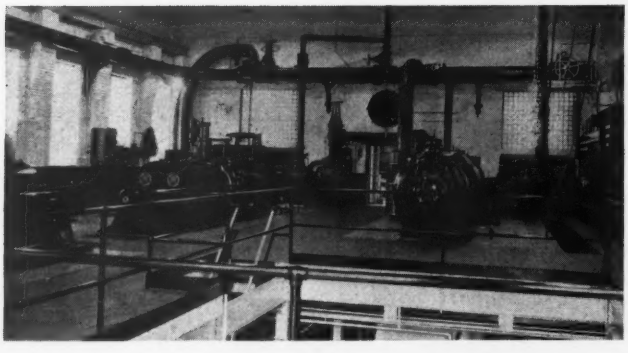


Fig. 8. Left. A view in the new turbine room showing the two new turbo-generators at the left

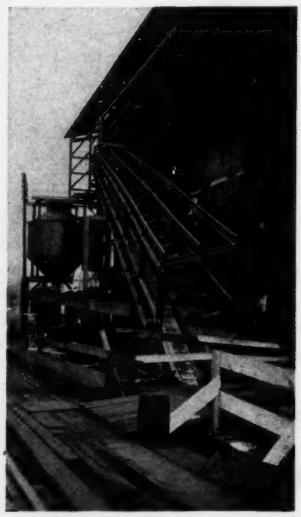


Fig. 9. The new inclined belt coal conveyor which delivers coal to the main distributing conveyor above the coal bunker

The five induced draft fans were installed on a new floor built over the top of the reconstructed boilers. Each of these serve one of the boilers and connect into a separate stack.

Forced draft is furnished by three fans feeding into a common duct. These are installed on the ground or basement floor. The induced draft fans are all driven by turbines through reducing gears. Because of their location above the boilers, these gears ran quite hot but this condition was overcome by the installation of oil coolers. Two of the forced draft fans are turbine driven and one motor driven.

The forced and induced draft fans and the stack dampers are controlled automatically by the Brooks system of combustion control but the stokers are controlled manually.

Each of these new boiler units will develop around 120,000 lb. of steam per hr. The average steam load runs about 430,000 lb. per hr. and ordinarily all of the boilers are kept on the line, though three of them could handle the load if necessity demanded. The coal used runs around 14,212 B.t.u. per lb. and with this coal a boiler efficiency of from 75 to 80 per cent is maintained. When this is compared with an average of 60 per cent for the old boiler plant, the value of the modernizing program is readily apparent.

The work involved in the rehabilitation of the prime mover equipment was simpler, though none the less important. Here a turbine and an old 1000-hp. engine and d.c. generator were removed to make way for two new bleeder turbo-generators. One old turbine still remains. Present equipment consists of the two new Westinghouse turbo-generators, an old 2500 kw. 600 v. General Electric condensing turbo-generator and an old motor generator set.

The new generating units are rated at 3125 kv-a., 3600 r.p.m., 600/2300 v., 100 per cent p.f. and have direct connected exciters. They are both of the bleeder type. One of the units operates condensing on an old barometric condenser; the other exhausts into a 1250 sq. ft. feedwater heater and operates at about one pound pressure.

These turbine units supply practically all the electrical energy needed by the mill. There is another turbo-generator in one of the mill buildings which takes steam from an old 400-hp. double tandem engine driving the beater line shafts, and an emergency connection is still maintained with the West Penn Power Co. but no power is purchased under normal conditions.

Although the foregoing describes the work of rehabilitating this power plant only very briefly, it shows what can be done to improve the operating economy of equipment which from any other standpoint is obsolete. These boilers were still fit for service but they were obsolete from the standpoint of size and design. By rebuilding them, however, using the old drums and as many of the tubes as possible, and by equipping them with modern underfeed stokers, they were made to fit into the power program for a number of years to come.

As is obvious from the fact that the steam load runs around 430,000 lb. per hr., the question of power cost is an important one at this plant and a rehabilitation program that effects a saving of 15 or 20 per cent in the boiler efficiency is deserving of careful consideration.

This paper mill, as a matter of interest, is one supplying the publications of the Curtis Publishing Co. and its entire output is used in the making of the Saturday Evening Post.

In presenting this brief description, we wish to acknowledge our indebtedness to C. P. Putnam, Manager of the Engineering Department and to J. P. Fry, the mechanical engineer at the plant for courtesies extended in the collection of the material used in this article.

Principal Equipment in the New Power Plant at Castanea Paper Co., Johnsonburg, Pa.

Boilers. 5 rebuilt, 4 drum Erie City Iron Works boilers, each of which is rated to generate 120,000 lb. of steam per hr. at 175 lb. pressure.

Stokers. 5—10 retort, 41 tuyere, PH-7 Taylor stokers with double roll clinker grinders, driven by Heleshaw LP 12 stoker drives. American Engineering Co.

Water Walls. Front, side and arch. American Engineering Co.

Brickwork. General Refractories
Harbison-Walker
North American

Boiler Baffles. Enco Cross Baffles

Water Columns. No. 5 Reliance with high and low pressure alarms. Reliance Gauge Column Co.

Feedwater Regulators. 2 Copes 3 in. Type BI on each boiler. Northern Equipment Co.

Also 2 S-C, type SL differential valves ahead of the Copes regulators. Swartwout Co.

Soot Blowers. Vulcan Soot Blower Corp.

Blow-off Valves—On Water Wall Header. Yarnall-Waring Co.

Safety Valves. Consolidated

Coal Scales. Richardson Scale Co. right and left hand on each boiler.

Forced Draft Fans. 3 Double width, double inlet Turbovane. B. F. Sturtevant Co.

Induced Draft Fans. 5 Turbovane. B. F. Sturtevant Co.

Fan and Damper Control. Brooke Engineering Co.

Valves. All valves in steam lines up to 10 in. Chapman Valve Mfg. Co. Small valves, Jenkins Bros.

Non-Return Valves. Edward Valve & Mfg. Co.

Piping. Crane Co.

Soot Burning Arrangement. United Conveyors Corp.

Ash Handling. Fairfield Engineering Co.

Coal Handling. Sprout Waldron & Co., Inc.

Coal Crusher. Stephens-Adamson Co.

Car Puller. Brown Fayro Co.

Turbine-Generators. 2 Westinghouse bleeder units, 3125 kv-a., 3600 r.p.m., 600/2300 v., 100 per cent p.f. 3 phase 60 cycle with direct connected exciter.

Switchboard. 15 panel. General Electric Co.

Few people in this world are more concerned with the processes of heat transfer and evaporation than the steam power plant engineer. In modern practice single boilers evaporate as much as 1,250,000 lb. of water per hr. A knowledge of the fundamental principles involved in the mechanism of heat transfer and evaporation perhaps not strictly essential will add considerably to the engineers appreciation of the processes under his control. It is with the idea of stimulating this interest along this line that we present this brief treatise on the subject.

Mechanism of Heat Transfer by Evaporation

By ALLEN G. STIMSON
Industrial Control Engineering Dept.
General Electric Company
Schenectady, N. Y.

HEAT TRANSMISSION by evaporation is an important industrial as well as biological process. Nature depends partly upon the evaporation of perspiration to maintain the body temperature. Man depends upon the evaporation of a liquid for steam power, refrigeration, oil refining, air conditioning, and many other processes.

The evaporation of a liquid under controlled conditions may be a stable, consistent, and continuous operation as in a power boiler or an electric refrigerator. Under unfavorable conditions the rate of evaporation may be very erratic and uncertain. In the design of new and especially unique types of evaporators, adherence to certain fundamental design criteria is mandatory if the product is to perform according to its proposed rating. The design of an evaporator follows from calculations to determine the proper surface areas. These computations are based on empirical data correlated in terms of a unit called the heat transfer coefficient. The accuracy of the calculations depends upon the selection of the most appropriate value of this coefficient. The performance of the product depends upon how closely the design of the evaporator approaches the ideal conditions represented by the coefficient. If the many conditions and factors which influence the rate of evaporation are critically considered in respect to the design of an evaporator, then that equipment should perform according to expectations.

In this first part of this article are discussed the fundamental mechanisms of the process of evaporation based on the molecular theory. The phenomena of surface tension and surface energy and the effect of these concepts on surface wetability and vapor bubble origination is examined in detail.

In a second part to be published in a subsequent issue will be discussed the observations and theory incident to the superheating of a boiling liquid, the critical sizes of bubbles and drops, the heat transfer coefficient, and the tangible factors which influence the coefficient.

PART 1

General Mechanism

Evaporation is fundamentally a mass-transfer process and the rate is a function of pressure difference rather than temperature difference. The heat transfer is accomplished by the latent heat in the mass transferred.

Evaporation may take place without boiling of the liquid but the corresponding rate of heat transfer is low. In the design of heat exchanging equipment economy of material and space makes forced evaporation by boiling mandatory.

The process of boiling involves several mechanisms which may be explained on the basis of the molecular theory. In practice a liquid is usually boiled by applying heat to the containing vessel. This heat passes through the wall of the container by conduction, into the liquid and then to the generated vapor. At the boiling point the vapor pressure in the liquid must be equal to the total pressure above its free surface. But ebullition cannot take place until the liquid is superheated, that is, the temperature is greater

than that required for saturation at the given pressure. The smaller the bubbles the greater is the superheat required to produce boiling. Although this superheat is necessary it should be kept as small as possible. Theoretically, infinite pressure is required for a bubble to form spontaneously in the body of the liquid. Hence, the bubbles form on the surface of the container. The bubbles forming on the solid surface must break away from it and rise to the surface of the liquid in order to allow room for additional bubbles to form. This detachment is facilitated if the liquid wets the solid which in turn depends upon the mutual condition of surface tension.

There is a minimum size bubble required to produce ebullition. Bubbles smaller than this minimum are collapsed by the surface tension while large bubbles grow in size, break loose from the heating surface, and rise to the liquid surface.

All of these restrictions placed upon bubble formation may explain why ebullition may take place only upon particular spots of the heating surface, where temperature and surface conditions are most appropriate. These points of vaporization may move and may even be cooler than adjacent spots although the surface is uniformly heated.

These observations suggest that evaporation is a rather uncertain process compared with other methods of heat transfer. Tests to determine the heat transfer coefficient have produced relatively discordant results because of the difficulty of measurement and the inconsistency of the process itself. The rate of boiling has been observed ([5]) to vary periodically even while all external controllable conditions were maintained constant.

The foregoing discussion indicates that each of the mechanisms involved in evaporation must be investigated in detail before the over-all process can be fully understood.

Surface Tension

Internal forces exist between the particles in a liquid just as they do in a solid but the manifestation is more difficult to perceive since a liquid offers negligible resistance to distortion. One investigator[1] demonstrated the existence of such forces by sealing a glass tube full of hot water. The water continued to fill the tube as it cooled and ultimately exerted a negative pressure of over 70 lb. per sq. in. on the walls of the tube. Since this negative pressure was many times greater than that obtainable from a vacuum, the water itself must have been under considerable tension. The fact that the water in the tube did not evaporate and fill the tube with its own vapor indicates that the cooling operation superheated the water so that it was actually under tension until the superheat was sufficient to permit bubble formation. These powerful forces which exist between the particles of a liquid must be overcome when the liquid is evaporated, and considerable energy (latent heat) is required.

[5]The references will be found at the end of the article.

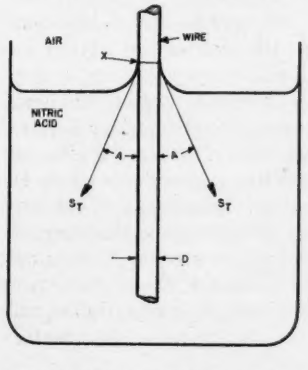


Fig. 1. The tenuous platinum wire was too weak to withstand the pull due to the surface tension

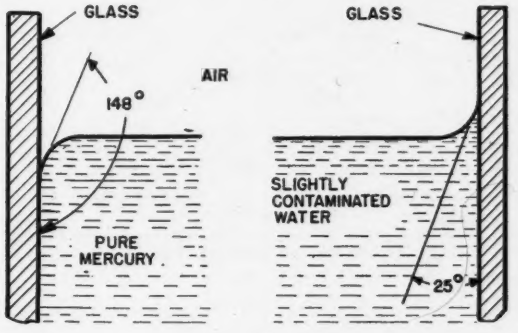


Fig. 2. The angle of capillarity is the angle at which a liquid surface makes contact with a solid

The sphere of influence of these molecular forces is so small that the thinnest solid immersed in a liquid separates the particles so far that the forces acting on the solid are negligible.

The molecular forces acting at the surface of the liquid produce an effect known as surface tension. This tension among other phenomena makes the surface of the liquid contract to the smallest area admissible. Thus a drop of one fluid tends to become spherical when suspended in another homogeneous fluid with which it is not miscible. This phenomena follows from the fact that surface tension involves potential energy known as surface energy which must have a minimum value for the equilibrium condition. The molecules whose sphere of influence is entirely within the body of the liquid are acted upon by equal forces on all sides but those molecules whose sphere of influence is partly above the liquid surface are attracted toward the liquid more than toward the surface. To maintain equilibrium the surface molecules are drawn closer together so that their mutual attractions are greater. Thus, the liquid surface is of greater density than the body of the liquid and has many properties similar to those of an elastic membrane.

The magnitude of this surface tension depends upon the substance with which the liquid is in contact. Dr. Howlett found that a very tenuous platinum wire could not be removed from the nitric acid used for cleaning because the force required to break the surface tension exceeded the strength of the wire. However, when a layer of ether was placed on top of the acid the wire was readily removed since both the acid-ether and ether-air surface tensions were much less than the acid-air tension. When the wire was pulled through the liquid surface, the surface tension S_t produced a force on the wire at X equal to S_t Cos A dynes per cm. of wire circumference or a total of $F = \pi S_t D \text{ Cos } A$ dynes. The value of F for the acid-air surface exceeded the

strength of the wire whereas its value for the ether-air surface and the acid-ether surfaces was less than the strength of the wire and so permitted removal of the wire from the acid. The angle A is the angle at which the liquid surface makes contact with the wire and is called the angle of capillarity. Surface tension manifests itself in many other familiar ways.

The magnitude of surface tension may be defined as the force of contraction across a line of unit length in the surface of the liquid. It is frequently expressed

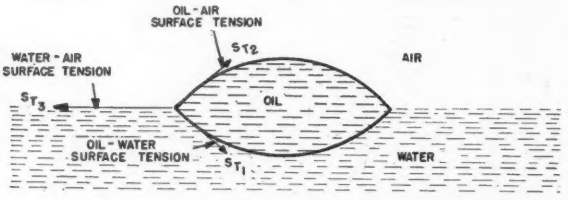


Fig. 3. A drop of water spreads over the surface of water because St_3 is greater than the resultant of St_1 and St_2

in dynes per cm. The following tensions (1) for air surfaces are expressed in these units.

Ether	17.6
Alcohol	24.5
Olive Oil	34.3
Water	73.5
Mercury	539.

The free surface of a liquid is horizontal but at the point where the surface meets a solid the surface curves upward or downward depending upon the type of liquid and surface. The angle at which this curved surface meets the solid is called the angle of capillarity (Fig. 2). Some typical values (1) of this angle are:

Very pure water in contact with clean glass	0°
Slightly contaminated water in contact with glass	25°
Pure mercury and glass	148°
Contaminated mercury and glass	140°
Turpentine and glass	17°
Petroleum and glass	26°

One influence of this angle of capillarity "A" is found in the familiar capillary tube effect in which the liquid either rises above or falls below the level of the surrounding free liquid surface depending upon the materials used. The surface tension exerts a force proportional to cos "A" upon the column of liquid which must either rise or fall until the static head balances this force caused by the surface tension. If the meniscus is concave the liquid rises in the capillary tube while if it is convex it is depressed.

If three substances are in contact along a common line, the tensions in the three surfaces must be in equilibrium, that is, the sum of the component forces in any direction must be zero. In case the tension in one surface exceeds the sum of the other two the three substances cannot meet at a common line. As an illustration, a drop of oil placed on the surface of water will tend to spread evenly over the entire surface of the water (Fig. 3).

Wetted and Non-wetted Surfaces

Jakob and Fritz (2) found that the surface tension influenced bubble formation at the heating surface of a boiling liquid. If the liquid wets the heating surface ebullition is facilitated. The tendency of the liquid to wet the surface depends upon the angle of capillarity. A drop of water on a clean glass surface spreads out in an effort to establish the small angle of capillarity while a drop of mercury tends to assume a spherical shape because of the large angle of capillarity. Thus, the water wets the glass surface whereas the mercury does not.

Figure 4 (3) shows the effect of wetability on the formation of a bubble at the heating surface. In the case of the wetted surface the liquid tends to establish the small angle of capillarity and thereby shears off the bubble at the surface. When the liquid does not wet the surface the bubble tends to spread out over the surface and is not released until it becomes large. Hence, the bubble insulates the surface and greatly reduces the surface area available for the transfer of heat.

Even in the case of the wetted surface if the heat supply is too great the bubbles are formed at the surface so quickly that the main body of liquid is insulated from the surface by a film of vapor. Under this condition the rate of heat transfer is greatly diminished. In power boilers where a high rate of vaporization is required the liquid is passed over the heating surface at a relatively high velocity to prevent formation of the vapor film and consequent over heating of the boiler tubes.

The formation of the insulating vapor film will take place even at moderate temperatures if the pressure is reduced.

Dupré (4) found that the energy required to form the vapor film of the original bubble at the heating surface depended upon the angle of capillarity. When

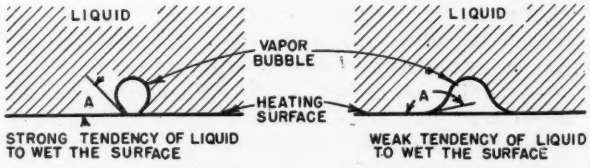


Fig. 4. Showing the effect of wettability on the formation of a bubble at the heating surface

the liquid does not wet the surface ($A = 180°$) the energy is zero whereas in the case of the wetted surface the energy is twice the surface tension. However, as was shown above, the flow of heat or energy from the non-wetted surface is restricted so that the overall transfer of energy is less. But, if the supply of heat originates in the liquid itself as when the pressure is reduced below the boiling point, the non-wetted condition may be advantageous because the vapor film does not restrict the flow of heat. In a new mercury boiler the liquid is heated under high pressure so that vaporization cannot occur during the heating process.

Surface Energy

As pointed out previously a particle within the homogeneous body of a liquid is attracted equally in all directions but when the sphere of influence of the molecular forces is partly above the surface additional forces from adjacent particles must act upon it to maintain equilibrium. Hence, work must be done to move a particle from the body of the liquid to the surface. The potential energy thus stored in the surface is known as surface energy.

The relation between surface energy and surface tension may be written:

$$S_e = S_t - T\frac{d\,S_t}{d\,T} \qquad (1)$$

where

S_e = Surface energy (ft. lb. per sq. ft.)
S_t = Surface tension (lb. per ft.)
T = Absolute temperature

The Formation of Bubbles

The vapor pressure within a bubble in the body of a liquid must be greater than the pressure in the liquid adjacent to the bubble in order to withstand the collapsing force due to the surface tension of the film enclosing the bubble. This excess of pressure p within the bubble is a function of the bubble diameter D and the surface tension S_t according to the following relation:

$$p = \frac{4\,S_t}{D} \qquad (2)$$

Equation (2) applies to a spherical bubble.

Now, if D = 0 the value of p would be infinite for all finite values of S_t. Theoretically, this result precludes the formation of vapor bubbles within the body of the liquid. The bubble in a boiling liquid must then form on the surface of the container. Jakob and Fritz (2) found this observation to be correct and it has also been verified by Philipp and Tiffany.

The size of a bubble rising toward the surface increases more than would be expected from the reduction in hydrostatic pressure. Hence, the amount of vapor within the bubble must be increasing and the latent heat must come from the surrounding liquid. In addition, since the bubble is at the same temperature as the surrounding liquid but at a higher pressure, the liquid must be superheated before it can boil. However, if the bubble contained a noncondensible gas the superheating required by surface tension would be less.

The method in which bubbles originate is not definitely known. The latent heat in the bubble apparently comes from the sensible heat in the superheated liquid. Some investigators think that the bubbles form about the points of microscopic projections on the heating surface. Another theory is that the bubbles originate in minute cavities in the heating surface which the liquid does not wet.

References

1. A. W. Duff, "Physics" P. Blakiston's Son & Co. (1926).

2. Jakob & Fritz, Forsch.—Gebiete Ingenieurw Vol. 2, p. 434 (1931).

3. McAdams, "Heat Transmission" McGraw-Hill (1933).

4. Dupré, "Theorie Mecanique de la Chaleur" 369 (1869).

5. W. J. King, "Heat Transmission," Mech. Eng., Aug. 1932.

6. Claassen, "Mitt Forschungsarb," V. 4, p. 49 (1902).

7. Max Jakob, "Heat Transfer in Evaporation and Condensation, Mech. Eng., Oct., 1936.

8. F. Bosnjakovic, Technische Mechanik und Thermodynamik, Vol. 1, p. 358, 1930.

Note: This is the first of two articles by the author on this subject. The second or part II will appear in a subsequent issue.

Power-house engineers have looked over the fence into the yard of the distribution fellows and gotten an idea. The low-voltage network as used for dependable power distribution in the larger cities has appealed to power-plant men as the solution of one of their tough problems—a thoroughly reliable power supply for the auxiliaries. In fact, modifications of the scheme have been devised.

One uses the 208-v. network system, relying on faults on the low-voltage side burning clear, and therefore not requiring attention from the operator.

The system is laid out as in the case of the conventional network and any feed to the network can be lost and still carry peak load. Therefore, the loss of a primary feed is something that need not be taken care of immediately but rather can be investigated at the leisure of the operator. From a cost viewpoint it is as cheap as any other scheme where the size of motors are such as to give reasonable control equipment for these motors and also a reasonable cost of motor supply from the network.

The success of the 208-v. scheme, hinged on a new 20,000 amp., 600-v., air-break switch. The transformer that has proved so successful in the low-voltage distribution networks is also useful on the 208-v. auxiliary supply scheme. It consists of a standard network transformer with a high-voltage, three-position switch and a standard submersible-type network protector mounted directly on the tank.

For larger installations, when breakers are used to clear the faults, the 440-v. network is used, in a system in which the motor supply feeders are so interlaced that the loss of a bus will not mean the complete shutdown of the station.

In this scheme the motors are grouped on bus sections and switches are provided to clear faults in the ties between bus sections forming the grid. As in the case of the 208-v. network, all of the motors are connected to a common grid. The motors are interlaced on the different buses so that the loss of a bus section will not mean the complete shutdown of a unit but rather will mean that the unit can continue in operation although at a slightly reduced capacity. (From the Westinghouse Engineering Progress report.)

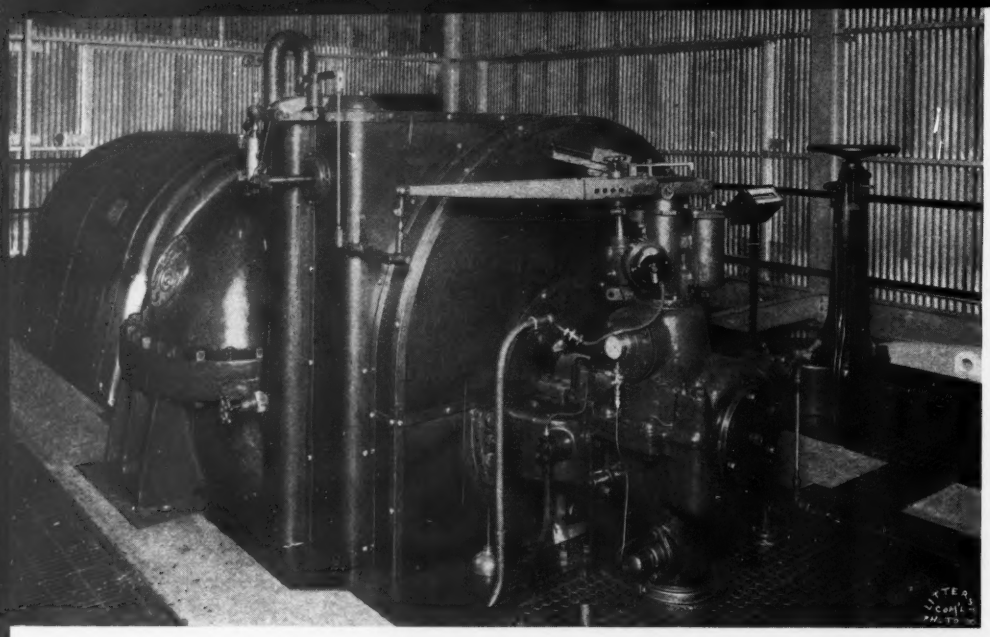


Fig. 1. Low pressure condensing steam turbine generator set, 2500 kw., 60 cycles

MODERN TURBINES*

By L. E. NEWMAN
Turbine Div., General Electric Co.
Lynn, Massachusetts.

LOW PRESSURE condensing steam turbines generate low cost power from steam which might otherwise be thrown away. Steam for these turbines may come from heating line returns, or from the exhausts of steam engines or steam hammers, or it may come from any source discarding waste steam at about atmospheric pressure. There is more energy available for power in this steam at atmospheric pressure when sent through a turbine and exhausted to a condenser than there is in steam entering a turbine at 200 lb. pressure and exhausted at atmospheric pressure. A simple, easily used method is given in this article for estimating the steam rates of these low pressure condensing turbines.

*Re-publication rights reserved by author.

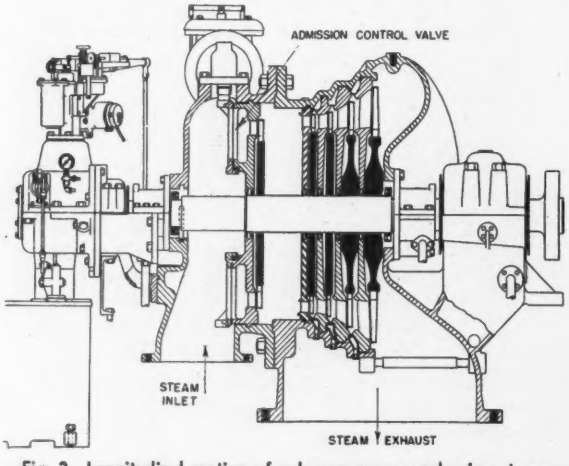


Fig. 2. Longitudinal section of a low pressure condensing steam turbine

First though, let's fit these turbines into our understanding of the other types of turbines. Like the superposed turbine they operate in a range outside the usual range of main pressures; they, too, can generate additional power at low cost without increasing the total quantity of fuel burned; and they, too, often pay for themselves out of savings after a brief term of operation. And again, like the superposed turbine, their field of application is a limited one. Similarity between the superposed and the low pressure condensing turbine ends here.

In contrast to the superposed turbine which is inherently suited for design in large ratings, the low pressure condensing turbine is limited to relatively low ratings. Compared to what has been built, 5000 kw. is a small rating for a superposed turbine, but a low pressure condensing turbine rated 5000 kw. would be approaching the upper feasible limit for units of this type so far developed. The same size inlet and exhaust, for example, that enabled a 1000 kw. low pressure condensing turbine to carry full load would be easily big enough for the steam flow required by a 50,000 kw. superposed turbine admitting steam at 1200 lb. pressure and exhausting it at 225 lb.

Because these low pressure turbines operate on waste steam and generate needed additional power without requiring new boilers they became known as

depression turbines. In plants where existing boilers were supplying steam for noncondensing turbines, the low pressure turbine was sometimes added as the low pressure element of a cross-compound set. Power developed from the new low pressure section was usually about equal to the power developed by the existing noncondensing turbine forming the high pressure element.

For these and similar applications the low pressure turbine has no competitor. Reciprocating steam engines can be built, theoretically, to operate condensing when supplied with steam at atmospheric pressure. But their cumbersome size and excessive cost rules them out for these applications. Relatively, a turbine is neither overlarge nor high in cost, and when operated with waste steam at atmospheric pressure generates power at high efficiency.

Figure 1 illustrates a 2500 kw. low pressure condensing turbine generator set designed for steam conditions of 20 lb. G, 0 deg. F superheat at the throttle, and 3 in. abs. at the exhaust. At full load this turbine delivers a kilowatt hour of power from less than 25 lb. of steam. This turbine has a 16 in. steam inlet and a 42 in. exhaust and in cross section appears as illustrated in Fig. 2.

Note the type of valve, Fig. 3, used on this turbine. It is an annular grid valve capable of controlling large volumes of steam at low pressure. Because the steam flow goes up in almost direct proportion to an increase in rated output, *the admission control valve is the limiting feature of low pressure condensing steam turbines.* As the rating is increased the volume of steam entering the turbine becomes so great that it is no longer feasible to build a valve capable of controlling it.

This type of control valve is commonly used for turbines extracting or admitting steam at relatively low pressure and having a large flow of steam passing through the valve to the exhaust section. In fact, Fig. 4 is a cross-section of an automatic extraction turbine and illustrates the similarity between its low pressure section and the complete low pressure turbine shown in Fig. 2. In reality a low pressure turbine is simply an automatic extraction turbine (or more properly a mixed-pressure turbine) with its high pressure section omitted.

So much for a description of the construction features of these turbines. Now to consider the easy problem of estimating their performance by working typical examples.

From the method, Figs. 5 and 6, steam rates of low pressure condensing turbines can be quickly estimated within a maximum error of 10 per cent (actually seldom exceeding 5 per cent). This short cut method covers any low pressure condensing steam turbine generator set rated 500 to 7500 kw. at 50 or 60 cycles. Two or three minutes is more than ample time to allow for estimating the full load and half load steam rates of one of these turbines. And you can leave your steam chart, slide rule and technical education at home while using this method. It is simple, direct, and accurate.

Let's take as our first example the 2500 kw. low pressure condensing turbine generator set previously described. Then, we have given conditions of:

"Subterposed"

Superposed turbines are "tops" in the opinion of many power plant engineers. Likewise any new turbines designed for low pressure steam would be "bottoms" in their opinion. But as Mr. Newman shows in this article there are often real savings to be had by working on the lower end of your steam cycle—savings just as real as those obtained by superposed turbines on the upper end of the cycle. These low pressure turbines have borne no special name through the years. Now with high pressure noncondensing turbines called "superposed," perhaps we should call these low pressure condensing turbines by a special name such as "subterposed."

Rating: 2500 kw., 0.8 P.F., 60 cycle.
Steam Conditions:
Main pressure 20 lb. G (35 lb. abs.)
Initial superheat, 0 deg. F.
Exhaust pressure, 3 in. Hg. abs.

In this, and the next example, the absolute main pressure, 35 lb. abs., was obtained by adding atmospheric pressure at sea level, 15 lb. abs., to the gage pressure of 20 lb. Actually, 14.7 lb. abs. is a closer approximation of atmospheric pressure at sea level, but 15 lb. abs. is easier to remember and introduces a negligible error.

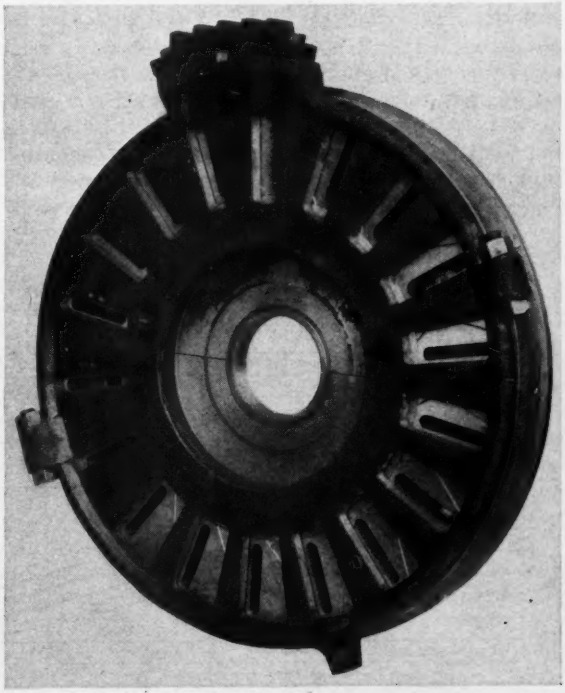


Fig. 3. Admission control valve for low pressure condensing steam turbine

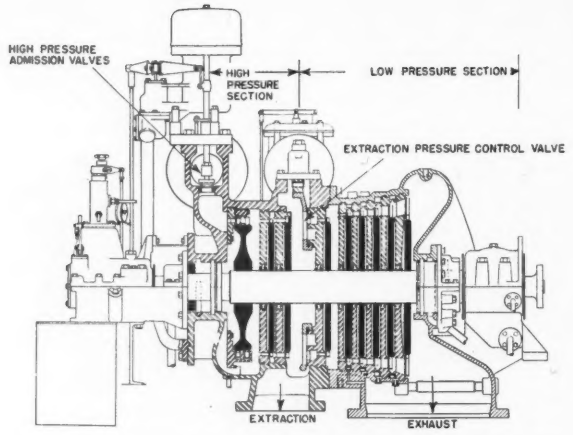


Fig. 4. Section through a condensing extraction steam turbine illustrating the similarity between its low pressure section and the complete low pressure condensing turbine shown in Fig. 2

Estimated performance of this turbine is:

Col. 1 Load, in kw.	Col. 2 TSR, in lb./kw-hr.	Col. 3 TSR Factor	Col. 4 SR in lb./kw-hr.
1250	16.8	1.595	26.8
2500	16.8	1.440	24.2

Explanation:

Col. 1; one-half and full rated output in kw.

Col. 2; Theoretical steam rate read from the chart, Fig. 5 at steam conditions of 35 lb. abs., 0 deg. F., and 3 in. abs.

Col. 3; Theoretical steam rate factors at one-half and full load, read from the chart, Fig. 6, at 2500 kw. rating.

Col. 4; Estimated steam rates in lb./kw.-hr., obtained by multiplying Col. 2 by Col. 3.

More often than not the object of preliminary studies of this type of application will be to determine the rating and performance of a turbine generator set to develop power from a given quantity of waste steam. Suppose then, for this example, that noncondensing engines are assumed to be discarding an average steam flow of 30,000 lb./hr. at substantially atmospheric exhaust pressure. And the problem is to determine how much power can be generated from this waste steam.

Briefly stated, the conditions are these:

Rating: to determine
Steam conditions:
Main pressure: 0 lb. G., (15 lb. abs.)
Initial superheat: 0 deg. F.
Exhaust pressure: 2 in. abs. (assumed)
Steam flow available: 30,000 lb./hr.

With a little practice the proper rating for given steam conditions and a given steam flow can be determined by inspection. But until then a first approximation of the rating may be obtained from this formula:

$$\text{Approximate rating} = \frac{\text{Steam Flow}}{\text{TSR} \times 1.5}$$

$$= \frac{30{,}000}{20 \times 1.5}$$

$$= 1000 \text{ kw.}$$

Now a tabulation like this can be set up:

Col. 1 Load, in kw.	Col. 2 TSR, in lb./kw-hr.	Col. 3 TSR Factor	Col. 4 SR, in lb./kw-hr.	Col. 5 Steam Flow, in lb./hr.
500	20.0	1.74	34.8	17,400
963 (by interpolation)				30,000 (given)
1000	20.0	1.55	31.0	31,000

Where, forgetting the middle line for a moment,

Col. 1, 500 and 1000 equal one-half and full load.

Col. 2, Theoretical steam rate read from Fig. 5 at steam conditions of 15 lb. abs., 0 deg. F., and 2 in. abs.

Col. 3, Theoretical steam rate factor read from Fig. 6 at 1000 kw. rating.

Col. 4, Steam rate at one-half and full load obtained by multiplying Col. 3 by Col. 4.

Col. 5, Total steam flow to the turbine obtained by multiplying the steam rate in Col. 4 by the corresponding load in Col. 1.

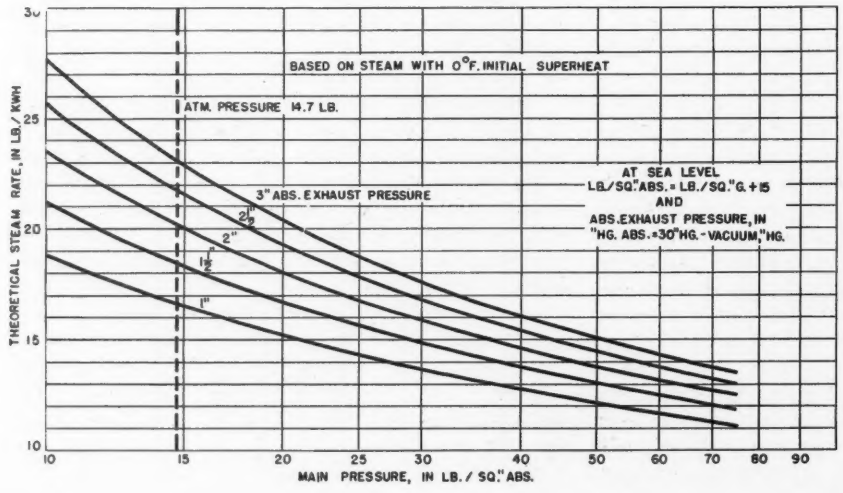


Fig. 5. Approximate theoretical steam rates of a low pressure condensing turbine based on steam with 0 deg. F. initial superheat

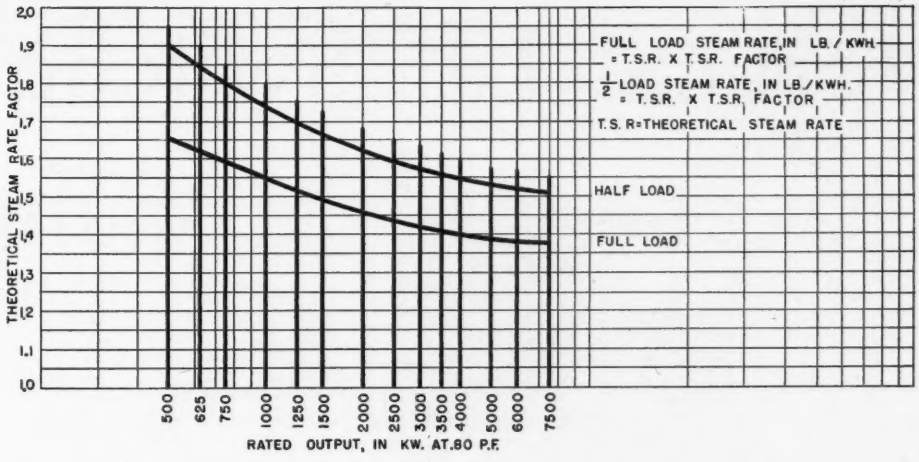


Fig. 6. Curves giving the approximate theoretical steam rate factors for low pressure condensing turbine-generator sets

The actual output, 963 kw., of this particular turbine at a steam flow of 30,000 lb./hr. may be obtained by straight line interpolation between the steam flow of 17,400 lb./hr. at half load of 500 kw. and the steam flow of 31,000 lb./hr. at full load of 1000 kw.

So far our method enables us to estimate the performance of only those low pressure turbines operating with steam at 0 deg. F. superheat. If the steam is superheated or contains some moisture the steam rates should be estimated exactly the same as if the steam were dry and saturated at 0 deg. F. superheat; then these corrections to the steam rate should be made:

For each 25 deg. F. superheat, decrease the steam rates for 0 deg. F. superheat by 2 per cent.

For each 1 per cent of moisture, increase the steam rates for 0 deg. F. superheat by 2 per cent.

An occasional disadvantage to the installation of a straight low pressure condensing steam turbine is its inability to generate power from high pressure steam when the supply of waste low pressure steam falls below the demand for power. In such cases the problem can be solved by installing a mixed pressure turbine capable of being operated with high pressure steam supplementing the low pressure steam. A mixed pressure turbine is simply a low pressure turbine preceded by a high pressure section, and in construction does not differ from an extraction turbine such as illustrated in Fig. 4. Such a turbine will generate power from low pressure steam in preference to high pressure steam, taking only enough high pressure steam to satisfy the additional load requirements over and above the load that can be carried on low pressure steam alone.

Of the various types of turbines so far discussed, low pressure condensing turbines are limited to the smallest field of use, but are probably most easily applied when their installation is justified. It is true that they will mean the installation of additional condensing equipment which in certain cases represents a serious draw back. But if there is ample cooling water available for a condenser, if steam at low pressure is now being wasted, and if additional power can be used the probabilities are that a new low pressure condensing turbine will save enough to pay for itself within a relatively short time. If your preliminary study indicates that such an installation may be profitable, let an outside consultant or a manufacturer's turbine specialist go over your figures. They can tell you whether the installation of a low pressure condensing turbine will pay you dividends or possibly point out why one does not fit your particular conditions. If your conditions justify one, additional power can be obtained without increasing by a pound the total quantity of fuel burned.

Bearing Wear

In general, the problem of journal and bearing wear is not so great in turbine and electrical apparatus as in other fields, for example, in the oil engine, N. L. Mochel of Westinghouse told the Wear Symposium of the A. S. T. M. Smooth operation, the use of conservative loads, pumping in oil under pressure before starting up, and careful attention to lubrication, minimizes the wear experienced.

At one time, lead-base babbitt was largely used for generator bearings, and others. Attack of the lead by acid conditions in the oil often resulted in rapid wear. Today, genuine babbitt has almost entirely replaced the lead-base babbitt for the purpose, and has entirely overcome the trouble.

Some difficulty has been experienced in trying to operate some of the newer corrosion-resisting steels in babbitt. Wear and minor seizure have occurred, and the entire matter required further study.

Non-metallic laminated bearings are being universally applied to practically all types of rolling in the iron and steel industry. These are made of a fine fabric and special synthetic resinoids, and molded under extremely high pressure, with directional properties carefully considered. These Micarta bearings are now finding successful application in the power-equipment field.

Rubber bearings and Micarta bearings are used to advantage in various pumps, in which the bearing is submerged and water is used as the lubricant.

Micarta has been used to replace *lignum vitae* in tail shaft bearings for ships, and in marine pumps. It has also replaced lignum vitae in the lower bearing of hydraulic turbines.

Vertical Lift Switchgear Simplifies

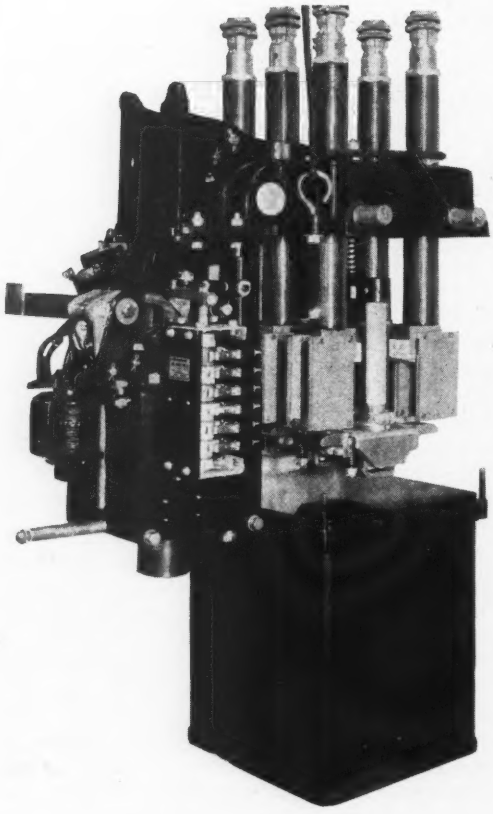


Fig. 1. Breaker unit with tank lowered showing construction, condenser bushings and arc interrupting devices. For manually operated units the coverplate and handle bolt directly to the breaker unit in place of the solenoid mechanism.

WITH the recent development of a new low capacity oil circuit breaker giving rapid arc extinction, a new era has been made available for the smaller power stations. Now they have the same opportunity for safety features and streamline appearance that their larger prototypes have enjoyed for a decade. If first cost were not a consideration these smaller plants would of course have made use of the larger sizes. But who can afford to ignore economics in operating his business?

Vertical lift gear has been limited in the past to those sizes of oil circuit breakers which do not depend on porcelain bushings for the insulation of the studs. For the disconnecting devices are mounted directly on the external end of the breaker stud, and so the bushing must have sufficient strength to withstand the stress exerted upon it when the breaker is elevated to its operating position in the metal clad cell.

The larger oil circuit breakers were equipped with treated paper bushings, generally in some form of condenser design, because the inherent strength of such bushings was demanded by the exigency of high short circuit rupturing ability. The users of such capacity breakers were therefore in a position to reap the benefits of vertical lift metal clad switchgear and have done so for many years.

The tremendous popularity of such design was due to many factors departing from older switchgear practice. The disconnecting devices which supersede the old circuit breaker disconnect switch, afford a silver to silver contact with much higher contact pressure. It gives in addition a gang operated, interlocked mechanism of such utter simplicity that all users of oil circuit breakers have yearned for the day when their size of switchgear could be so equipped.

That day is here. Whether it is a generating plant with its multiplicity of control protection and metering features or a transformer substation with its less complex requirements, there is a vertical lift switchgear design for such application. In capacity the sizes available follow the standard rating of oil circuit breakers ranging from 25,000 kv-a. short circuit up to almost any limit. This article is primarily interested in the smaller sizes, say, 25,000 kv-a., 50,000 kv-a., and 100,000 kv-a.

For a number of years factory fabrication of switchgear with group shipment and installation of the units has been followed in metal clad construction. For the smaller plant a factory made combination of the high tension equipment in its protected cell with the switchboard panels is very desirable. But a number of complications result if exact duplication of old conventional practice is followed.

Analysis of these complications and the application of corrective measures has not only produced a design that meets every need afforded by the outmoded system, but yielded in addition simplification of operation; increase in safety; reduction in field construction expense, and improvement in appearance, almost beyond belief. And all this can be had at essentially the same cost installed ready for operation, as that of the superseded construction.

The metal clad switchgear design makes use of a hinged front panel which provides space for the instruments, the relays and the control and instrument switches, indicating lamps and features for testing the switchboard devices. These panel mounted details have all been so designed that mounting upon a hinged

Small Power Stations

By L. L. MELLERS
Engineering Division
Westinghouse Electric & Mfg. Co., Chicago, Ill.

panel is an improvement over the stationary panel since generally much better access is procured at the rear of the panel to inspect the wiring installed there. But hand operated knife switches for exciters and generator field circuits and hand wheel mechanisms for rheostats present a mounting problem on such

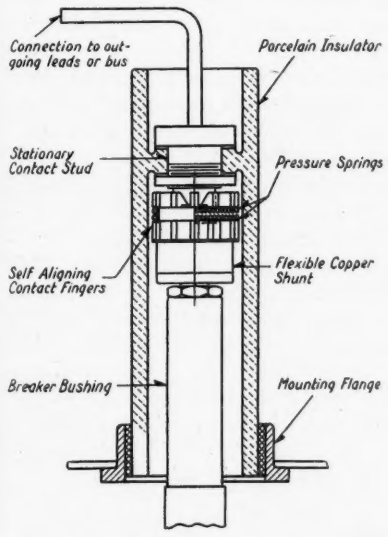


Fig. 2. Details of primary disconnecting device.

panels. In the past they have been mounted rigid immediately behind the hinged panel which has been cut out sufficiently to not only permit operation of the device when the panel is closed, but to clear such device when opening the panel.

These cutout sections detract from the appearance of the finished ensemble and certainly do not increase the mechanical strength and rigidity of the panel, but this problem too had its solution.

The great majority of the smaller size generating plants use direct connected exciters for each generator unit. Thus there is no need for exciter switches for nothing is gained by parellel operation of direct connected exciters. In fact, the opposite is true for additional expense must be made for exciter and generator instruments and switches; paralleling the units is required; and in addition the characteristics of the exciters must match each other perfectly or there is trouble ahead. This eliminates one half of the switches.

There is no necessity of opening the field switch when taking a generator unit out of service. The shutting down of the prime mover fundamentally removes the voltage from both the exciter and generator field. The rare occasion when it may be desired to open the field circuit can be taken care of by mounting a field switch in a small cabinet located preferably in the basement beneath the exciter and generally on top of the field rheostat. This cabinet also provides protection for the field ammeter shunt and the discharge resistor.

This eliminates all knife switch factors from the hinged panel design. Further, it saves an appreciable item by avoiding the duplex runs of heavy conduit and

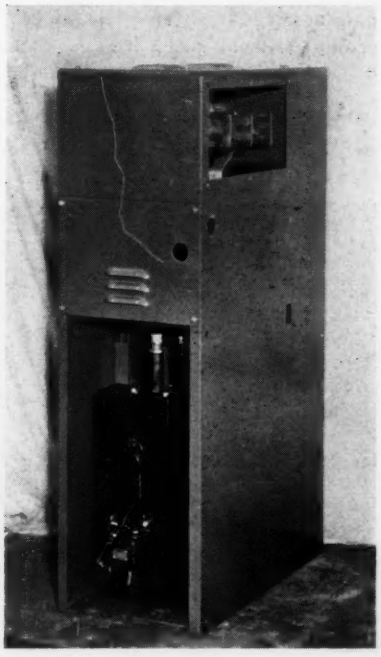


Fig. 3. Front view of the single unit.

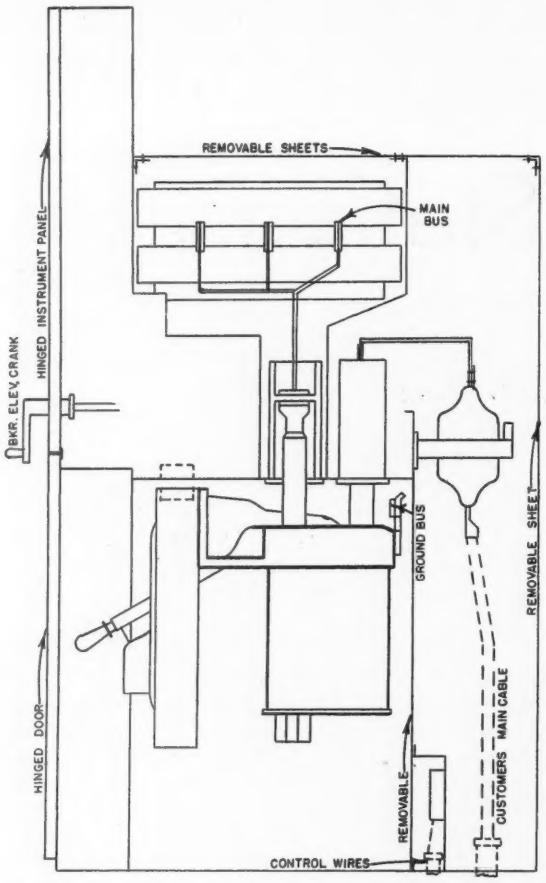


Fig. 4. Typical section of combined switchgear and panels.

cable from the exciter to the panel and immediately back again to the generator field; a point only a few feet from the start. The rear of the panel is improved in appearance because of the absence of large conduits and heavy wires. In their place five small wires of regular switchboard wire size give exciter voltage and field ammeter readings and shunt field control for the exciter.

Modern machine design has about eliminated the need for generator field rheostats if individual exciters are used. The voltage can be controlled exclusively by the exciter shunt field rheostat. At most a tapped resistor for initial adjustment when first starting up the plant may be required, which removed the worst problem; panel control of a remotely located rheostat.

The exciter rheostat is always a small compact piece of equipment and may be tripod mounted on the rear of a direct controlled mechanism, and is mounted on the voltage regulator section; rather than the generator panel. This is logical, since the voltage regulator functions by means of this rheostat and the cross connections from the various contacts of the voltage regulator to their respective field rheostats are localized in a single compartment.

The voltage regulator is mounted on a stationary panel which matches in appearance the swinging panels for the various circuits. At the rear are located the necessary accessories for the regulator and the entire unit is enclosed in a matching metal housing. A door at the side or rear of this cell gives access for any need.

Generator panels are now equipped only with details that are designed for hinged panel construction, without sacrifice of operating efficiency or safety.

For those plants not equipped with individual excitation a compact metal enclosed cell design will answer the problem—stationary front panels with inspection doors at the rear. All knife switches, exciter rheostats, bus bars and field switches are conveniently grouped. After the exciters have been paralleled and the field switch closed the remaining functions in starting up a new generator are the same.

Many of these small installations use hand operated oil circuit breakers because of the lower first cost. The preferable design is to mount these breakers in the same way as though they were electrically closed. This means that the hand closing lever is at the rear of the panel, but the improvement in appearance and the change of the tripping in error due to the projecting handle more than justify the slight inconvenience of opening the door to reclose the breakers. The switchboard panel has been made in two sections so that the operating door may be opened and yet leave the instrument visible in their normal position.

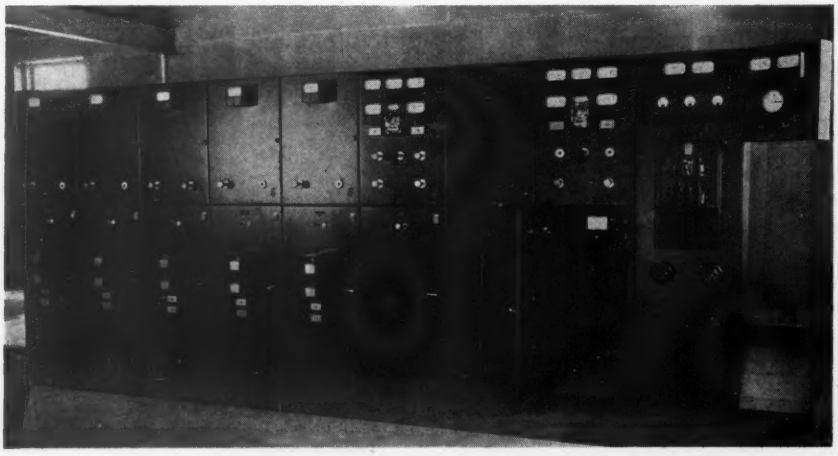


Fig. 5. Compartment door opened to operate oil circuit breaker or to remove breaker unit.

Fuel and Operation Affect Diesel Deposits

After extended tests made to show the influence of fuel types and operating conditions on Diesel engine deposits the authors tell the S. A. E. Engineers that the designer has greater control over these deposits than either the oil refiner or the engine operator

By J. R. MACGREGOR and W. V. HANLEY
Standard Oil Co. of California

MOST PUBLISHED INFORMATION on the performance of fuels in high speed Diesel engines has dealt with the initiation of, or, delay in initiation of, combustion. Considerably less work has been done on the later phases of the combustion process which includes the rate of burning, duration of combustion, and completeness of burning.

To study the combustion processes an accelerated test was developed to yield results which would correlate with deposits in popular service engines. After preliminary tests had indicated the type of engine most subject to the formation of deposits, the first step was to determine the effect of operating conditions in this engine on deposition, in order to select a set of conditions which would furnished reproducible results in a short time. Two well known and commonly used types of lubricants were tried in order to select the lubricant which would contribute the least to engine deposits. Load has an influence on engine deposits and tests were carried out, covering a range from idle to three-quarters, to evaluate its effect in the test engine. As shown by Fig. 1 the total deposit idling was approximately five times that at three-quarters load.

Effect of load is partially attributable to changes in engine temperature and a range of the operating temperatures that are subject to control was therefore investigated. The temperatures controlled were intake air, jacket and lubricating oil. Lowering the intake temperatures from 150 to 100 deg. F. increased the deposit in the combustion chamber but had no effect on exhaust valve deposit.

An increase in deposit except at the nozzle, resulted from a decrease in jacket temperature from 200 to 150 deg. F. However, when comparing results shown for 150 with those of 125 deg. F. very little change is indicated, the difference being within the range of experimental error. Likewise a change in lubricating oil temperature from 130 to 160 deg. F. was found to have no appreciable effect, the difference in deposits being less than the experimental error.

Excessive fuel quantities or over-rich mixtures are known to also increase deposits in Diesel engines. In normal sea-level operation the air-fuel ratio could not be reduced by means of increasing the fuel quantity without, at the same time, increasing the load and the combustion chamber temperatures, both of which had previously been found to minimize the formations of deposits. Therefore, at idle load, the intake air was throttled to simulate altitude operation in an effort to obtain rich mixtures as well as low operating temperatures. As shown by Fig. 2 the total engine deposit was approximately doubled by the simulated change of 7000 ft. in altitude. The fuel used in these tests did not cause the rings to stick under any operating conditions within the 24-hr. period, but ring stick-

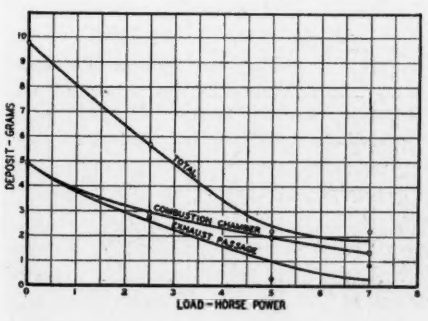
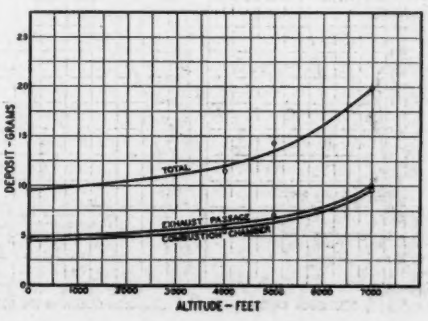


Fig. 1. (Left) Effect of load on engine deposits showing the increase at light loads

Fig. 2. (Right) Altitude, too, has an appreciable effect on engine deposits



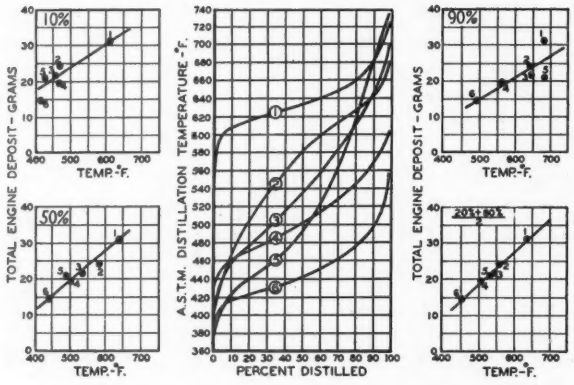


Fig. 3. Tests made to show the effect of A.S.T.M. distillation on engine deposits show good correlation between deposits and average volatility at 20 and 80 per cent distillation temperatures. The 50 per cent temperature correlation is poorer but affords a reasonably accurate criterion

ing was obtained in subsequent tests with certain fuels at the higher altitudes even though no ring sticking occurred with those fuels at sea-level.

The above tests indicated that large quantities of deposit could be obtained in a relatively short time by the proper choice of operating conditions. The combustion chamber deposit was substantially constant after 24 hours while in the exhaust passages the deposit increased continuously with increase in running time. Apparently the high temperature and turbulance existing within the combustion chamber caused the deposit to be removed as rapidly as formed after a certain point had been reached. That this point was reached before 24 hr. was verified by later tests with heavy residual type fuels in which it was found, that, unless sufficient combustion chamber deposit was formed before 24 hours to stop the engine, failure did not occur from this cause regardless of the length of run. In addition, these tests showed that with residual type fuels, and also with certain distillate fuels, the exhaust deposit was occasionally of sufficient magnitude to stop the engine. This occurred at a varying number of hours of running time beyond 24 hr.

From the results obtained in the preliminary investigation of operating variables it was possible to select a set of operating conditions for an accelerated test for Diesel fuel deposition. The following set of test conditions was selected: Load, idle; speed, 800 r.p.m.; altitude, 5000 ft.; duration of test, 24 hr.; jacket temperature, 150 deg. F.; lubricating oil temperature, 130 to 160 deg. F.

To determine if the accelerated test was sufficiently reproducible, a typical straight run distillate fuel was retested at intervals over a four month period. The average results of four check tests with deposits given in grams were: Combustion chamber, 7.59; nozzle, 0.24; exhaust valve, 0.62; total, 14.86.

Considering the magnitude of the deposits obtained, as shown by the average values, the reproducibility is considered satisfactory for this method of measurement. Further correlating tests were required, however, to determine if the differences between fuels of various physical properties, indicated by this laboratory test method, would be indicative of results obtained in other service engines under more normal operating conditions.

Physical Properties and Engine Deposits

Volatility is a common physical property which varies widely in marketed Diesel fuels. There have been differences of opinion as to the proper volatility range required for high speed Diesel engines and to determine the effect of volatility on engine deposition various cuts of a normal fuel were selected. These special distillates were prepared to cover a range in boiling points wider than normally encountered in commercial fuels. That particular care was required in the distillation of such fuels was indicated by a test in which 1 per cent of residual type Diesel fuel was added to a normal distillate. In this case the nozzle deposit was increased 10 times and the exhaust valve deposit was approximately doubled. This effect was avoided in the special fuels selected for the volatility test by the use of good fractionation. The distillation data for the fuels used are shown in Fig. 3 as well as the results obtained in the deposition tests. The best correlation of engine deposit with volatility is indicated by the average volatility as computed from the 20 per cent and 80 per cent A.S.T.M. distillation temperatures. The 50 per cent point provided slightly poorer correlation but for convenience, affords a reasonably accurate criterion. The 10 per cent and 90 per cent temperatures showed no consistent relation to engine deposits.

Conradson Carbon has been commonly used as an indication of the burning qualities of Diesel fuels. An attempt was therefore made to correlate Conradson Carbon and engine deposits for a variety of fuels.

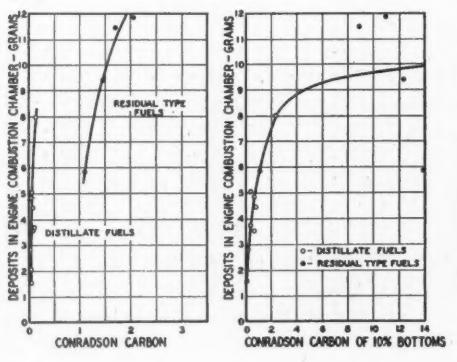
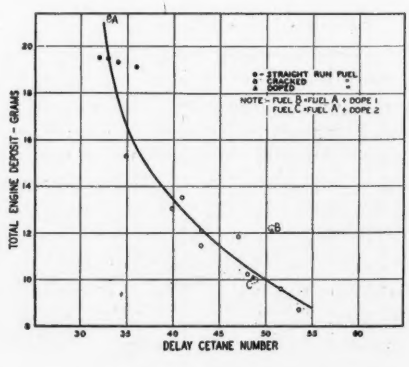

DEPOSITS IN ENGINE COMBUSTION CHAMBER - GRAMS
RESIDUAL TYPE FUELS
DISTILLATE FUELS
CONRADSON CARBON
o - DISTILLATE FUELS
• - RESIDUAL TYPE FUELS
CONRADSON CARBON OF 10% BOTTOMS

Fig. 4. (Left) Correlation of combustion chamber deposits with Conradson carbon residue tests

Fig. 7. (Right) Effect of delay Cetane No. on engine deposits. The correlation for all fuels is fair when the Cetane No. is determined by the Magnetic Pickup Delay Method but the critical Compression Pressure Method was found to be less exact


TOTAL ENGINE DEPOSIT - GRAMS
o - STRAIGHT RUN FUEL
• CRACKED
▲ DOPED
NOTE - FUEL B = FUEL A + DOPE 1
FUEL C = FUEL A + DOPE 2
DELAY CETANE NUMBER

As shown by Fig. 4, for normal distillate fuels, the Conradson Carbon values were so nearly alike and close to the minimum measurable, that this carbon residue test failed to indicate the relative engine deposition. For residuel type fuels of the A.S.T.M. Classification No. 4 type and heavier, good agreement was indicated between Conradson Carbon and engine deposits.

The Conradson Carbon of the 10 per cent bottoms from the conventional A.S.T.M. gas oil distillation of burner fuels has been proposed as an indication of burning performance. Figure 4 shows that for the normal distillate fuels or distillates with small amounts of contaminants this carbon residue test provided a fair indication of engine deposition. For residual fuels no correlation is apparent.

Ring Sticking

There are indications that the engine deposits with normal distillate fuels depended somewhat on the ignition quality and the relation shown in Fig. 5 was obtained by plotting engine deposition results versus cetane numbers as determined by the Magnetic Pickup Delay Method. A fair correlation was indicated for all the fuels tested including straight run, cracked and doped fuels. Correlation with cetane number determined by a Critical Compression Pressure Method was found to be somewhat less exact. The results shown for doped fuels are of special interest. Two entirely different types of dopes were added to the same low cetane fuel and the engine deposits obtained were in close agreement with the improvement in cetane number.

Although ring sticking was not as reproducible as the other phases of the tests, frequent ring sticking occurred during the check tests with the low cetane undoped fuel. The reduction in deposits with the doped fuels might have been the result of solvent action of the dopes on the deposit. However, the use of two widely different types of dopes with similar results is believed to have precluded this possibility. An examination of Fig. 5 shows that the cracked fuels were intermediate to the extremes of the distillates. In this engine this appeared to be merely a function of cetane number and the general conclusion that all cracked fuels cause greater engine deposits than straight run fuels is apparently not justified.

Service Engines

The direct injection engine used in the laboratory tests was chosen because it was known to be critical to fuel deposition characteristics. Tests were therefore made in three other popular makes of high speed Diesel engines to determine the degree of correlation between the fuel sensitive direct injection engine and other service engines. The first engine was of the pre-combustion chamber type and a variety of fuels, including straight run and cracked distillates and residual types, was investigated. The correlation between the deposits in this engine and the test engine was good for the exhaust valve deposits. Within the combustion chamber correlation as fair indicated for the distillate fuels and poor for the residual type fuels. At the nozzle, although the correlation with distillates was good, no correlation existed for the residual fuels.

This may be explained by the different types of nozzles employed. In the engine in which the nozzle deposits were greatest, a three hole nozzle was used, while in the other engine the pintle type was employed. Similar operating conditions were used in the two engines and the total combustion chamber deposits are within the same range for the distillate fuels. For the residual fuels a marked increase in the deposit compared to the poorest distillate fuel was found in the direct injection engine, while in the pre-combustion chamber engine, the deposit with the residual fuels was only slightly greater than for the poorest distillate fuels. The exhaust valve deposit in this engine was smaller than in the direct injection engine for all fuels.

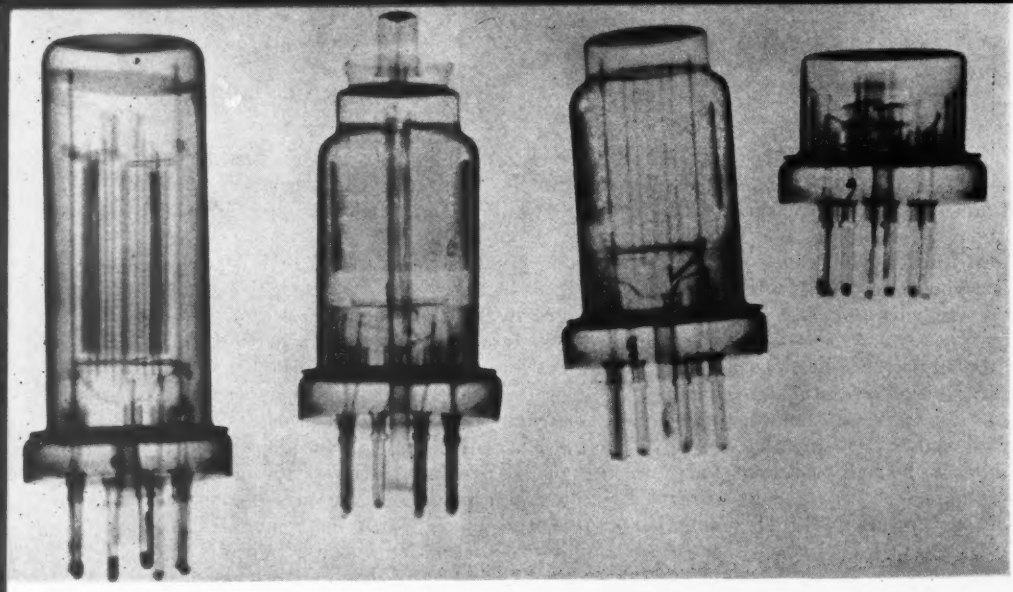
In summary it may be concluded that in these Diesel engines which are critical to fuel deposition, a decrease in operating temperature and load or an increase in altitude increases the quantity of deposits formed. In these engines increasing the average volatility or the cetane number of the fuel decreases the deposit.

The Designer's Problem

In those engines in which fuel deposition is slight no consistent difference between fuels and no correlation with physical properties of the fuels are apparent. These tests covering a wide variety of engine design, fuels and operating conditions have demonstrated that the engine designer has greater control over the quantity of deposits formed in the engine than either the fuel refiner or engine operator as indicated by the test results presented in which the ratio of deposits were 20 to 1 between extremes in engine design, 10 to 1 in operating conditions and 3 to 1 between extremes in distillate fuels.

Public Power in Nebraska

Sale of all the facilities of The Southern Nebraska Power Co., Superior, Nebraska, to the Central Nebraska Public Power and Irrigation District for $898,000 in cash has been approved by Federal Power Commission. This includes generating stations in the towns of Superior, Hebron, Oak, Deshler, Clay Center and Harvard, Nebraska; transmission and distribution facilities in Clay, Fillmore, Nuckolls and Thayer Counties, Nebraska; and a line extending from Hubbell, Nebraska, to a point within Kansas from which electric energy is transmitted further by facilities operated but not owned by Southern Nebraska to the town of Mahaska, Kansas, to which the company sells electric energy at wholesale. The Southern Nebraska company also distributes and sells energy to other consumers in Kansas located on or near the company's transmission line located along the boundary between the two states.



X-RAY VIEWS OF METAL ENVELOPE TUBES

Photo Courtesy, General Electric Co.

Electron T

Part XXVIII

By

A. W. KRAMER

IN ITS BROAD IMPLICATIONS, the electron tube is not so much a new device in electrical engineering as it is a new method. The great value of the electron tube in circuits lies not in its ability to do certain things in particular circuits but in the fact that it employs a special method of conducting electricity—one quite different from any that we had known before.

At any time, and for particular purposes, a tube may be either a resistor or a conductor, a rectifier or a capacitance, a generator or an insulator. None of these things are new, all of them have been with us for many years, since the beginning of the art of electricity in fact and if the electron tube was not something else besides these things there would be no reason for it to occupy the unique place it does in the electric art. But, the electron tube involves a specialized method of conducting electricity, by the motion of free electrons and other freely moving charges through a vacuum or gas-filled space, and it is this fact that sets it off, apart from other electrical apparatus which make use of only liquid or solid conductors.

Fundamentally all electric conduction involves the motion of free electrons or other moving charges, but the utility of the mode of conduction in the electron tube lies in the fact that the motions of the current carrying charges on which the translation of energy depends can be much more readily controlled when they are free in space than is possible when they are traveling in solid or liquid conductors. It is, moreover, easier to detect them; in the case of a Millikan electron charge measuring apparatus, the acquisition or gain of a single electron is easily detected. In the F.P.-54 tube described in an earlier chapter, as may be recalled, a current corresponding to a flow of six electrons per second can be measured.

Another thing of vast importance about this method of conduction is that the motion of the charges can be controlled not only by electrostatic or magnetic forces but by the action of light, that is, electromagnetic radiation. This is of profound significance. As was shown in the preceding article, in the case of the General Electric photoelectric recorder, the movement of a relatively rugged indicating device was controlled by a very weak measuring device, through the agency of a beam of light reflected from a mirror. This easily understood and commonly accepted fact is of outstanding importance and represents perhaps one of the greatest achievements of human endeavor in our control over the forces of nature. It gives us a control over matter by *immaterial* radiation. The fact that a beam of light, however powerful can affect the movement of even a single electron is more wonderful than if a fly were to move a locomotive.

Naturally any method of control over the movement of electric charges so sensitive and so flexible is of immense value in the field of measurement and instrumentation. The applications described in the

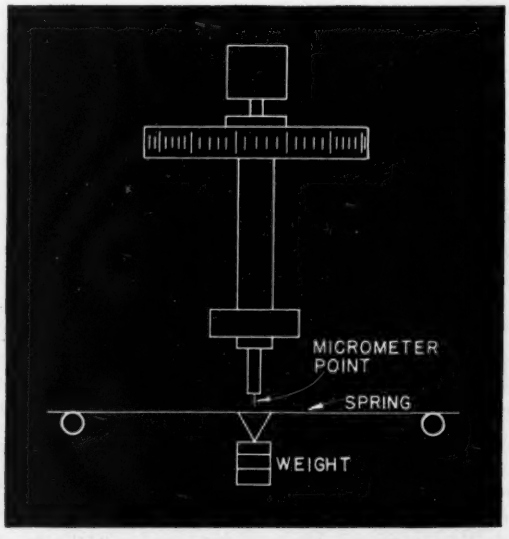


Fig. 1. Arrangement used in testing hereditary hysteresis of instrument springs. The element of spring ribbon is placed across two horizontal pins and loaded with a weight. The deflection is then measured by a micrometer which is so connected to a grid glow tube that the tube flashes at the instant the micrometer point makes contact with the spring

n Tubes—Principles and Applications

The easily understood and commonly accepted fact that the photocell enables us to control the movement of a material object by a beam of light represents one of our greatest scientific achievements in controlling the forces of nature.

preceding few chapters are typical examples of how the electron tube can be made to serve in the field of measurement, not only in the measurement of electrical quantities but also of physical or non-electrical values. The measurement of speed of a centrifuge operating at 100,000 revolutions per minute referred to in a previous chapter was an example of the latter type of measurement.

It is possible to translate every physical value into electrical terms; thus temperature can be measured in terms of the change in resistance of an electrical conductor or the electromotive force generated by a thermocouple; angular or linear velocity can be expressed in terms of magnetic fields or electromotive forces generated in conductors or piezo-electric crystals, stress or strain in materials can be measured by change in contact resistance, or by the piezo-electric effect. Fundamentally this conversion of physical values into electrical values by one means or another, need not involve electron tubes but here, as in practically every other case, the electron tube has extended the field of usefulness.

To show how electron tubes may be used in the measurement of non-electrical values a few examples will be given. The first concerns the measurement of the roughness of a commutator of a rotating electrical machine. In an application of the grid-controlled rectifier a measure of commutator roughness is made by determining the voltage variations when current is passed through a brush riding the surface of the commutator. If the surface is smooth, the voltage variations across the brush and the commutator are of the order of 2 volts with 110 v. applied. If a complete break occurs as would happen if the brush were lifted from the surface and let fall on the commutator, then. to make contact, the voltage variation would be 110 v.

Formerly the oscillograph was used to record the variations in brush drop voltage, but this method has two disadvantages: first, the degree of roughness cannot be determined at once because the films have to be developed and calibrated and second the oscillograph element has a certain inertia which prevents it from recording the maximum voltage peaks. To overcome these limitations the use of the grid-glow tube was suggested by the Research Laboratory of the Westinghouse Electric & Mfg. Co.

If a grid controlled rectifier tube is so arranged that its grid voltage can be varied in steps of 1 volt from zero to, say, 100 volts, and the brush drop connected in series so as to oppose this voltage, a means of measuring the brush voltage drop will be obtained.

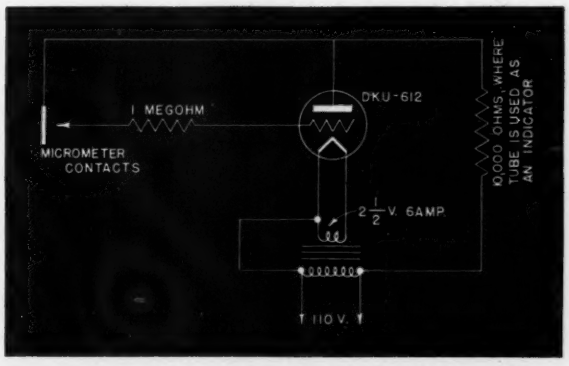


Fig. 2. The circuit used with the electron tube micrometer

By decreasing the grid voltage slowly from some high negative value and noting the value of the voltage at which the tube breaks down, it is possible to determine the brush voltage drop by simply referring to a curve showing the required grid voltage for the particular plate voltage used to make the tube conduct. A. M. Harrison of the Westinghouse Electric & Mfg. Co. who devised this scheme states that roughness of the order of 0.0001 in. can be measured in this way when the commutator is rotating at from 5000 to 10,000 ft. per min.

A similar application of the grid glow tube is had in the electron-tube micrometer. In some instances in industrial process control it is necessary to make exact measurements of very delicate or very ductile materials which may be deformed or broken by the pressure of the jaws of an ordinary micrometer, and also the operator's sense of touch may not be suffi-

ciently sensitive for making exact readings since the material must build up resistance to the micrometer screws.

By arranging a grid controlled rectifier in such a way that when contact is made between micrometer points and the object being measured, the tube will glow, the exact point of contact is easily and accurately determined. In this way extremely accurate micrometer measurements are made without the slightest pressure of the jaws upon the material. Of course in this case the micrometer is still the actual measuring instrument, the electron tube serving merely in place of our own sense of touch.

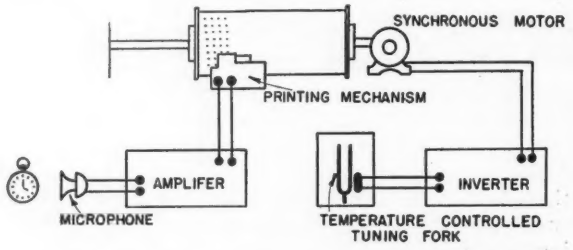


Fig. 3. An electron tube chronograph for the accurate measurement of short time intervals as is necessary in checking the accuracy of time pieces

With some devices of this type it is easily possible to take readings to the nearest 0.00001 in. The indicating device, however, is sensitive to changes which are very much smaller than those which can be read. By means of recording devices, movement of the micrometer barrel is mechanically magnified so that changes as small as 0.000002 in. can be read. This distance is about one-tenth of the wave length of green light and therefore is equivalent to one-tenth of a fringe in an interferometer.[1]

An interesting application of this principle is possible in the measurement of creep of metals at high temperatures. Those familiar with high pressure steam plant operation need no introduction to the importance of "creep" With the high sensitivity of measurement just referred to in a typical test, the creep in a certain specimen during the first 20 minutes after applying the load was 0.0097 in. After heat treatment the creep under the same load conditions was only 0.0013 in. Thus, instead of requiring days of time, the accurate determination of creep by the electron tube micrometer is obtained in a few minutes of testing.

This type of micrometer has also been used very successfully in the measurement of hereditary hysteresis effects in the manufacture of spiral springs for instruments. In this case a short length of spring was placed on two parallel horizontal pins and loaded with a weight as shown in Fig. 1. The deflection of the beam was measured with a micrometer head fitted with a sharp contact point. Contact between the micrometer point and the ribbon operated a grid glow tube to indicate the instant of contact. A large diameter drum and a magnifying lens was attached to the micrometer head to facilitate accurate readings; and a constant tension thread drive was used to make accurate settings of the micrometer.

These micrometers have been developed and used for specialized industrial measurements where extreme accuracy is important but they are simple to make as is evident from the circuit shown in Fig. 2 and any person with a little ingenuity can make one for any use where greater than ordinary accuracy is necessary.

[1]The interferometer measures minute distances by means of the interference between light waves. This interference manifests itself by a series of dark or colored lines or fringes which are a function of the distance being measured.

Measuring Short Time Intervals

Various schemes for the measurement of short time intervals have been developed using electron tubes but most of these are for highly specialized purposes in manufacturing processes and need not concern us particularly here. There is one, however, that may be of interest since most anyone is likely to encounter it. It has to do with the regulation of watches and clocks. All of us, at one time or another, have had a watch or clock at the jeweler's for regulation. Usually this took time—several days or a week, even longer.

With a new chronograph system, developed by Charles Young and Maurice Artzt of the R. C. A. Manufacturing Co., however, a watch can be accurately regulated in a few minutes' time by measuring the interval between ticks. It consists of a tuning fork, accurately temperature controlled, controlling the speed of a driving motor connected to a drum on which a visible record is made. The watch ticks are amplified after being picked up by a microphone and by means of a printer are recorded on a paper chart. Since the tuning fork serves as a time frequency standard, the intervals between ticks may be determined

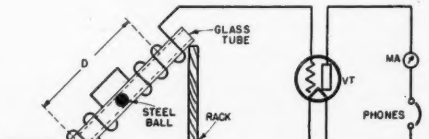


Fig. 4. A simple electron tube viscosity meter

with great accuracy. The time-keeping capacity of a watch may be determined to an accuracy of within 1 second a day in about 1 minute. The general scheme of the arrangement is shown in Fig. 3. An application such as this is of course quite outside of the ordinary run that might be encountered in industrial work, but it demonstrates the versatility of the electron tube. Electron tubes play their part at both ends of the system, first in the amplifier which amplifies the weak impulses of the microphone to a degree such that they are able to operate the printing mechanism, and second in converting the impulses of the tuning folk into alternating current for operating the synchronous driving motor. Fundamentally, the idea is very simple but it was quite impossible of attainment until the advent of electron tube amplifiers and rectifiers.

Another Timing Device

Quite different from the timing devices just described is a viscosity tester using electron tubes. In some manufacturing processes heavy viscous liquids are used and it is important that the viscosity of these liquids be maintained uniform. To test the viscosity of these liquids, the simple arrangement shown in Fig. 4 has been found very effective. It consists of an inclined glass tube surrounded by two coils connected as shown and in which the liquid to be tested is placed.

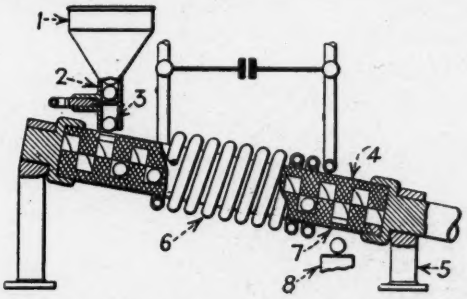


Fig. 5. An apparatus for surface hardening of ball bearings. Balls fed through funnel 1 are admitted, one by one, by means of trigger 2-3, into the tilted porcelain tube 4 which rotates in bearings 5. In rolling from one end of the tube to the other through the helicoidel channel provided in the tube the balls pass through the magnetic field of the high frequency coil 6 and then fall through the opening 7 into cooling liquid 8

A heavy steel ball is rolled through the liquid in the tube and as it passes through the coils it causes two successive clicks in a pair of headphones or two sudden movements of the pointer of a plate milliammeter. The time interval between the clicks is then a function of the viscosity of the liquid and it can be checked with a stop watch.

Surface Hardening

Similar in general arrangement to the above described viscosity tester is the device shown in Fig. 5. This is an arrangement for hardening the surface of ball bearings. In ball bearings as in many other steel parts of machinery, the entire load is carried by the peripheral zones alone, which at the same time are exposed to friction. It is necessary therefore to harden these outside zones only because the hardening of the whole section results in loss of tenacity between the interior layers of material which in most cases is highly undesirable.

Of all the known methods of surface hardening, one of the most perfect is that of treating steel with eddy currents. The part is inserted into the magnetic field of a coil energized by high frequency current. The eddy currents induced in the steel by this field cause the temperature of the outer layer to rise to the hardening point, after which the part is plunged into a cooling medium such as oil or water. As a result of this treatment the outside layer acquires a high degree of hardness while the inside retains its original tenacity. By varying the frequency and the power input to the coil it is possible to control the surface of the hardened layer and its structure.

The equipment shown in Fig. 5 described in a recent issue of "Electronics" by George Babat and Michael Losinsky of Leningrad, Russia, utilizes this principle of hardening, the high frequency currents being generated by power oscillator tubes. Balls fed through the funnel are admitted one by one, by means of a trigger, into a tilted porcelain tube which rotates in bearings. In rolling from the one end of the tube to the other through the helicoidal channel provided in the tube, the balls pass through the high intensity, high frequency, magnetic field at a uniform rate of speed and then fall through an opening at the bottom of the tube into the cooling liquid.

Although this last example is not an application in the field of measurement, it has been included here because it is characterized by extremely accurate control characteristics. Control is really a form of measurement, usually measurement between limits and as will be shown in subsequent articles, the principles involved in these measuring instruments are also embodied in control systems of various kinds. These few examples have been selected to show the wide range of applications of the electron tube in the field of measurement and instrumentation; each one has in it possibilities for many others.

Embrittlement of Boiler Steel

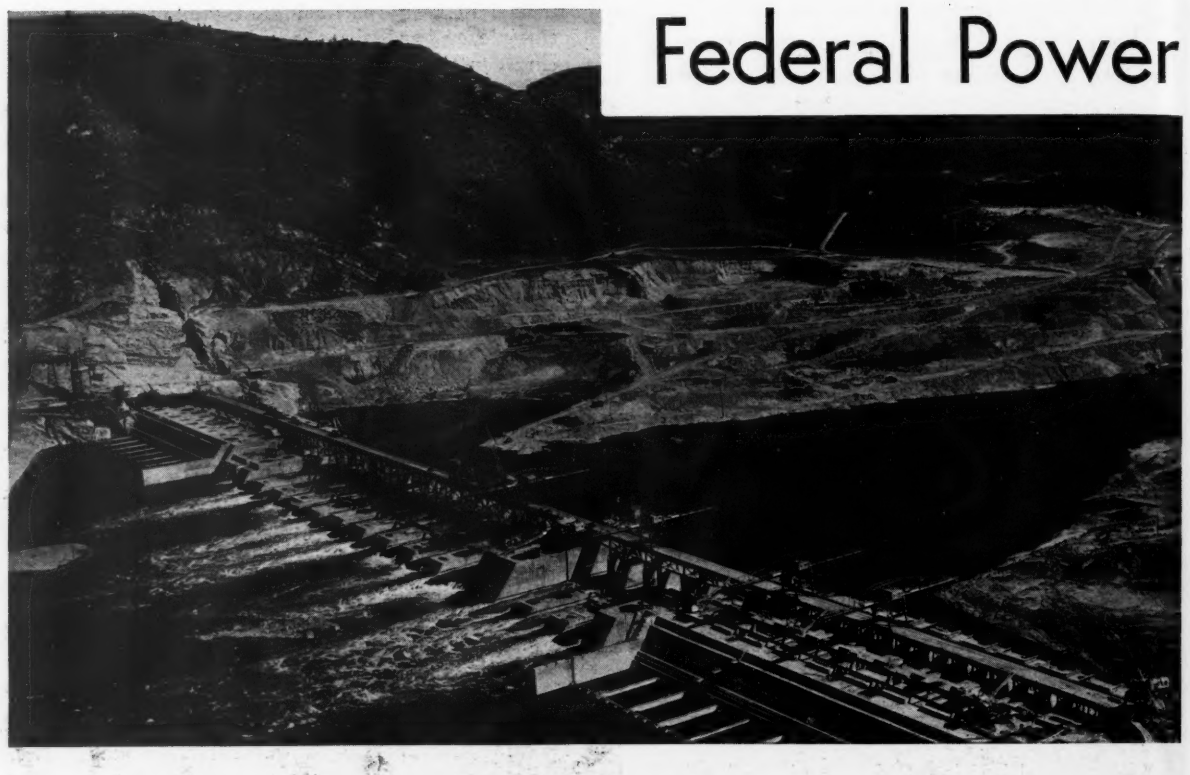
New knowledge regarding the cause of embrittlement of boiler steel, a matter of vital importance to manufacturers, power-plant operators, public utilities, and other large fuel users, has been obtained as the result of a study of intercrystalline cracking in such steel, conducted by the Bureau of Mines, United States Department of the Interior. The results of the investigation are summarized in a paper by W. C. Schroder, A. A. Berk and C. H. Fellows, presented at the meeting of the American Water Works Association, New Orleans, La., April 26.

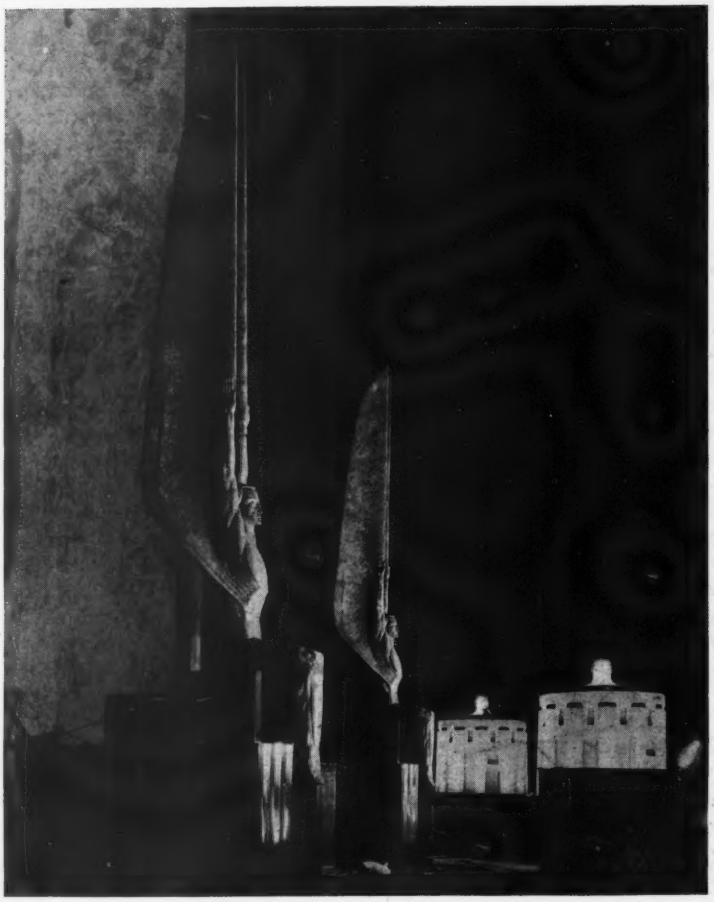
Research work previously conducted by the Bureau of Mines to establish a satisfactory basis for the use of sodium sulfate to prevent embrittlement indicated that existing knowledge concerning intercrystalline cracking was meager and contradictory. Many competent engineers responsible for boiler operation were of the opinion that the prevailing method of using sodium sulfate was not altogether satisfactory.

The Joint Research Committee on Boiler Feedwater Studies, therefore, instituted a study to determine the factors that produce embrittlement in boilers; whether the recommended method for using sodium sulfate would prevent embrittlement; and what means could be used if sodium sulfate was not satisfactory.

The laboratory results now show that cracking starts from selective corrosion of stressed grain boundaries, usually by sodium hydroxide-sodium silicate solutions. It proceeds through the metal both by selective corrosion and bursting forces exerted on the grain boundaries by the corrosion products that occupy a greater volume than the initial intergranular material. The laboratory experiments show that lignin and some other organic materials offer more protection than sodium sulfate. They can be used at pressure up to 550 lb. The lignin compounds are now being tested in operating boilers.

Federal Power





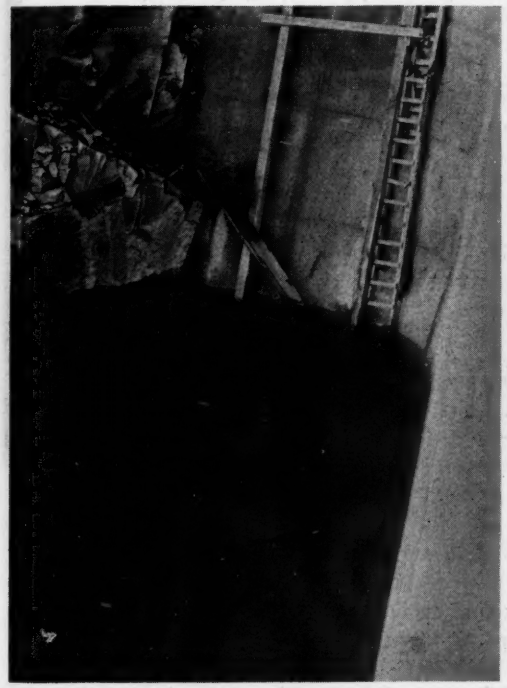
On these two pages we present some interesting views of the great Federal Power and flood control developments now under construction in the western part of our country. The enormity of some of these projects can scarcely be grasped by the average mind. The size of Grand Coulee, even now in its first stage of completion staggers the imagination. In the photograph above Grand Coulee is shown as it is today or rather as it was last month. The first stage is finished; now work is in progress to complete it to its full height of 550 ft.

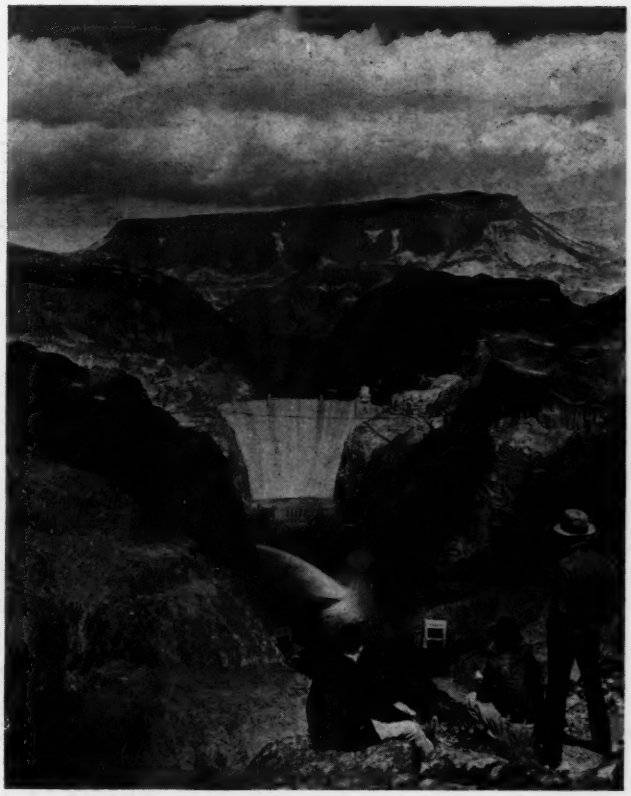
Not long ago Grand Coulee had a visitor. A beaver came up to look the dam over. No report of his opinion has been released but it appears he was quite aghast and somewhat disconsolate. It seems he had always taken pride in his dam building capabilities but when he saw how far man had beat him at his own game, he was sad.

At the left we have a striking night view of the figures of the Republic at Boulder Dam. Stretching their upraised wings 30 ft. above the crest of the dam they stand out clear against the dark desert sky. The Nevada wall of Black Canyon of the Colorado River rises above them. The lighted tops of the great intake towers immediately upstream from the dam can be seen at the right.

Developments in the West

Photos Courtesy Dept. of Reclamation





Here is an impressive picture of Boulder Dam. Built at a cost of two battleships this great dam will stand for many generations, a monument to engineering achievement and a work of growing value to all the people. As long as rain falls from the skies, the power of this dam will light the homes and relieve the burdens of the people of the Pacific Coast.

Above we see Mr. Beaver on his visit to Grand Coulee recently. He need not have been so sad about it because after all he never had the tools that the constructors of Grand Coulee have to help them.

Heavy construction has begun on the great Central Valley federal reclamation project in California with the award of contracts for the construction of Shasta Dam. This dam when completed will be the second largest in the world, second only to Grand Coulee. It will involve a power plant with a capacity of 350,000 kw. The dam will be 500 ft. high and 3500 ft. long—5,010,000 cu. yd. of concrete.

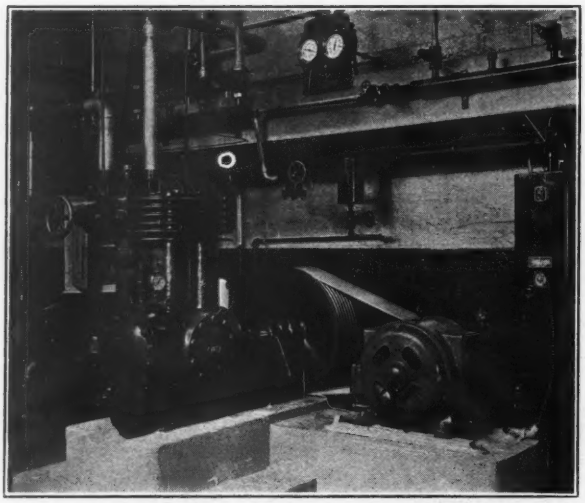


Fig. 1. A 7¾ by 5 in. Freon-12 compressor used throughout the year for air conditioning by the Charles E. Frost Co. of Canada

Factors that must be considered in designing machines for a new refrigerant and a new service, in this case Freon-12 and air conditioning

By Terry Mitchell, M. E.
Frick Co., Waynesboro, Pa.

Building Refrigerating Machines for Service

GROWING popularity of Freon-12 as a refrigerant, particularly for air conditioning work, has focused the attention of engineers and owners alike on equipment suitable for its use.

A compressor designed for this service must be compact, dependable, efficient and quiet in operation, and must be adapted within certain sizes to automatic control. Included with this last requirement must be some method of returning the oil to the crankcase of the machine, since the oil tends to go into solution with the Freon-12 and is carried with it throughout the piping system.

As is well known Freon-12 operates at lower pressures than ammonia, and a greater volume of the gas per ton of refrigeration must be handled by the compressor. The useful refrigerating effect of each pound of Freon-12 circulated in the system may be taken as 50.5 B.t.u. This is the net useful heat absorbed in evaporating a pound of the liquid at a suction pressure of 37 lb. ga., corresponding to a saturation temperature of 40 deg. F. Under identical temperatures, ammonia gives a net refrigerating effect of 463 B.t.u. per lb. On the other hand, Freon-12 gas under these conditions is approximately five times as heavy as ammonia gas, so the net result is that the cylinder displacement of a machine using Freon-12 for the above case would be 1.83 times as large per ton of refrigeration, as for one using ammonia.

It is of interest to see how one of the builders of Freon-12 equipment, the Frick Co., Waynesboro, Pa., has solved the problem of incorporating these features in a practical machine. Drawing on their experience in developing ammonia compressors, dating back to the pioneer days, it was decided to make the Freon-12 compressor of the enclosed type, having two vertical single-acting cylinders, with trunk pistons. The crankshaft, connecting rods, die-cast bearings, discharge valves, manifold stop valves, and as many of the auxiliary parts as possible that had proved their merits in ammonia service, were used in the new machine.

Compressor frames or columns were arranged to be one-piece castings, the design being adapted both to the requirements of Freon-12 and of modern production methods. As these machines run at higher speeds and as Freon-12 tends to leak more readily than most refrigerants, the importance of maintaining cylinder alinment and eliminating unnecessary joints was evident. Cylinders are cast integral with the crankcase and the bearing housing, adjacent to the shaft seal, is built into the frame, without any joint. Cooling fins are adopted for the cylinder heads of all machines except for the larger sizes, which are water-jacketed.

Castings are made of semi-steel and include sufficient amounts of chromium, nickel, silicon and manganese to give the desirable denseness, strength, machine-ability, and wear resistance. After being sand blasted, properly aged, cleaned and pressure tested, the cylinder walls are honed on a vertical machine which is, incidentally, the largest of its kind in the world. The three flanged openings on the side of the

frame, where the manifold valves and oil separator are bolted to it, are all on the same level or plane, to facilitate machining. This plan has been followed in locating the crankcase cover plates, openings for the bulls eyes, and the anchor bolts which are placed in pockets grouped around the base of the frame. The cylinder diameters are greater than the stroke and as actually built, the compressor sizes are, in inches: 5¾ by 4; 7¾ by 5; 8¾ by 6; 11½ by 8; 13¼ by 9; and 15 by 10.

The new pistons are arranged to permit the use of special suction valves of the multiple ring plate type, designed to handle the large volumes of Freon-12 by passing the gas on each side of the ring plates, eliminating necessary clearances, and be quiet, reliable, and efficient in operation. Curved valve ports are milled in the solid steel plate forming the top of the cage of each valve, which plate is threaded, screwed into place and pinned so that it cannot become loose. The entire valve cage is similarly fastened in the piston. The 11½ by 8, 13¼ by 9, and 15 by 10 sizes have three or more of these valves in each piston head.

Discharge valves follow the same general construction, but working under higher pressures and smaller volumes, do not require as great a lift as the suction valves. The discharge valves are assembled into a complete safety head, held down between the top of the cylinder and the cylinder head by heavy springs instead of bolts so as to allow the head to lift in case a slug of liquid Freon-12 or oil gets on top of the piston.

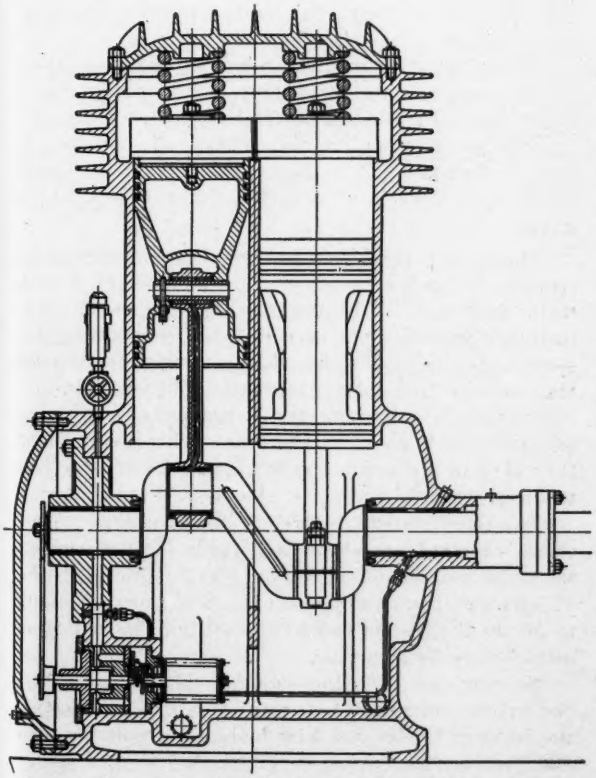


Fig. 2. Cross section through an enclosed type Freon compressor showing details of design and construction

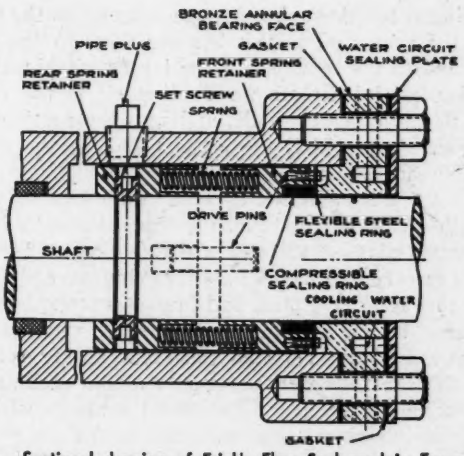


Fig. 3. Sectional drawing of Frick's Flexo-Seal used in Freon compressors for preventing leakage along the shaft

One of the primary problems in designing an enclosed type Freon-12 machine is that of lubrication. Freon-12 is miscible in oil and has the effect of dissolving the oil and carrying it out with the refrigerant. This condition is aggravated if liquid or saturated Freon-12 gas comes back through the suction lines to the machine and reaches the crankcase. In this case the warmer temperature of the crankcaes causes some of the Freon-12 to evaporate from the mixture of oil, and this results in foaming and a tendency to pump oil. The miscibility of oil and Freon-12 thus creates a problem, the solution of which is met by specially designed oiling arrangements both in the compressor itself and in the associated equipment.

Oil Separation

To recover the oil returning from the evaporator, where most of it is liberated from the liquid Freon-12, the suction gas is returned to the compressor through a separating trap at the suction of the compressor. From the trap the returned oil drains directly into the crankcase, a small plate being used as a baffle to keep the oil in the crankcase from being splashed back into the separator, while the gas passes directly to the suction part of the compressor.

Presence of Freon-12 gas in the oil would make it difficult to keep the force-feed oil pump primed if it were located at the end of the crankshaft, where a suction lift, as in standard ammonia practice would be required. Instead, the pump is placed in a pocket, at the bottom of the crankcase below the normal oil level, and is driven by a roller chain from a sprocket on the crankshaft. This arrangement, together with the fact that the shaft with its two cranks is inserted in the column from this side, accounts for the pear-shaped cover plate on the end of the column. The oil pump on its suction side is fitted with a self-cleaning Cuno filter, making a revolution every 30 sec., and driven by a small train of gears from the main oil pump drive. The pump itself is made reversible to take care of changes of direction in the rotation of the shaft. From the pump the oil is forced under pressure to the main bearing directly above, and from there goes through drilled passages and welded oil pipes to the cranks and wrist pins. The stuffing box

bearing is fed through a direct oil line from the pump and the excess oil to this bearing flows to the shaft seal and to the crankcase. The larger machines have mechanical lubricators for feeding oil to the thrust side of the cylinder walls, and into the suction line.

This shaft seal is the critical spot in the design of a Freon-12 compressor. Seals of the bellows type are not readily adapted because of the size involved. Details of the patented Flexo-Seal are shown by Fig. 3. The main parts of this seal are a ring secured by set-screws to the crankshaft; another ring, turned by the first through drive pins, and pressed outward by coil springs; a compressible sealing ring, which makes a gas-tight joint between the front spring retainer and the shaft, as well as against a thin sealing ring of flexible steel which rotates and contacts with the compressible ring on one side and on the other slides on a stationary annular bearing bronze face. The compressible sealing ring is made of a material not affected by Freon-12. The flexible steel sealing ring is turned by small drive pins and maintains a gas-tight seal against the polished surface of the bronze annular bearing, which itself is sealed by gaskets where it is bolted to the box.

Boiler Erection

Pulverizer Pete Is Loose Again

IT IS A LONG TIME since you hears from me Editor, which is because I was making a big study on how to put boilers up and I thinks you should be wised up on this business.

It comes to happen like this. I was sitting by a ash car where the boss can't see me, I hopes, when up walks the Erection super. from the company which is building us a boiler.

"Hello", sez I.

"Oh hell", sez he.

"What's bitin' you?"

"Thirty foot boilers in 29 point 9 foot spaces".

"Meaning which"? I asks, figuring he is nuts.

"It's like this", he sez, as I lights the cigar he hands me (after I ask for it). "A salesman is a dumb cluck what sells a 200,000 lb. boiler where there ain't space for a 10,000 pounder—the factory builds the boiler so it fits—if you doesn't paint it first—and the Erection gang is the suckers what get hell because we looses money putting it up."

"Furthermore," he starts again—the five o'clock whistle wakes me up and that night I decides to become a erection expert.

The first thing you needs for to erect up a boiler is steel work. This holds the boiler up from the bottom or down from the top—or maybe the boiler holds the steel up depending on how bum is the steel job. When you gets this up it won't be plumb. So you socks it with a sledge hammer until it's plumb some places anyway. Now it will look like you look when you look into a cheap looking glass.

Next you puts the drums in place and lines them up. (You should ought to have roller skates or maybe a little grease under them for to let them expand.) You work at this for a couple of days and then they still ain't in line so you goes ahead with the tubes. First you stick a tube in a hole in one drum, the other end of the tube goes in a hole in the other drum—maybe, and most likely no; so you socks it and jacks it until it goes in. The tubes should all lean like they look on the picture, if you can read a drawing, but maybe it is enough you should be satisfied to get the ends in the holes.

When a tube is stuck in a hole you should go quick and expand the end in before something slips and out comes the tube. After one end gets rolled in, the other end don't stick far enough in the other hole so you got to weld a little hunk on. This don't make it stick no tighter when you expands it but the inspector when he comes around will maybe think its ok. Sometimes when the tube ain't too short you can heats it with a torch until it expands enough to let you roll it.

By this time probably payday comes around so the next morning you spends getting your crew out of jail which they gets into because they gets cockeyed.

If you is lucky and gets them out you can start the brickwork. It don't make no difference what kind a brick you use because it all cracks up anyway when the fire starts. If you wants to use the boiler it is best you don't forget to leave holes for the burners, and maybe you better connect the boiler to the chimney because the boiler house will get full of smoke if you don't. You now puts up the casing and you is done. If the holes don't line up you pulls it around with a crowbar until they does. This makes the plates bend which don't matter no how for they buckles anyway when you starts up. If a joint between two plates is too wide you covers up this lousy job by saying it is an "expanshun joint".

Now you got to insure the boiler (and you better get some yourself also) which mean an inspector comes nosin' around and wants to make a hydrostatic test. If you tries this without my advice all you does is make a fountain out o the boiler and the inspector starts squawkin "Weld this, Weld that, Reroll that", so you better read what else I got to say.

There is three things you can do to fool the inspector. If you is up north you just fills the boiler with water and wait till it freezes. You can now let the inspector in and when he makes his hydrostatic test —man, that boiler is tight. If he is anxious for to look inside of the drums don't tell him I told you this.

If it ain't cold where you is just put the water in and wait till it rusts up the leaks. This works ok if they ain't to big which maybe happens even after you studies this article.

The third method is swell if you is nearby where there is a stable which has a horse in it. You sweeps the stable and throws what you picks up into the drum. This fixes up little leaks good but if the inspector wants to get in the drums you better tell him he will gets dirty before he gets wise.

So now, Ed., you knows how come these boilers you prints pictures of gets put up so if you likes this maybe soon I tells you how to boil out a boiler and make a customer think he is satisfied with a boiler when he ain't.

Power Plant Engineering Presents

Topics Talked About at Engineering Conventions

DURING the early weeks of this summer, many of the national engineering societies held meetings for the presentation of papers, reports of technical committees, and the laying of plans for further investigations into engineering subjects, the findings of which will be helpful to the profession. Obviously, only a portion of the topics discussed at any of these meetings dealt directly with power plant engineering, yet each of the societies in the field contributed something of value to designers and operators.

In the pages of the section which follows, a very earnest endeavor has been made to present in digest and comment form the thoughts expressed by speakers so that readers will have a fair picture of what progress is being made and the direction in which leaders in the field are pointing as the immediate course to follow. Ideas expressed and data presented have been summarized under headings which seem most appropriate and so far as possible the source of statements has been acknowledged in the text, although many of the opinions given are those of the editors who have written the comments.

With so great a number of papers and reports which have been read and carefully examined in the preparation of this digest, it has been possible only to mention briefly some of the more technical subjects treated in papers and the familiar topics discussed, thus permitting more space to be devoted to ideas with possibilties of immediate application.

This is an entirely new editorial method of presenting information gathered from a number of society meetings, which, it is hoped, will make interesting as well as profitable reading.

Society Meetings Reviewed

American Institute of Electrical Engineers—A.I.E.E.
Washington, D. C., June 20-24

American Society for Testing Materials—A.S.T.M.
Atlantic City, N. J., June 27-July 1

American Society of Heating and Ventilating Engineers—A.S.H.V.E.
Hot Springs, Va., June 20-22

American Society of Mechanical Engineers—A.S.M.E.
Oil and Gas Power Meeting, Dallas, Tex., June 6-8
Semi-Annual Meeting, St. Louis, Mo., June 20-23

Edison Electric Institute—E.E.I.
Atlantic City, N. J., June 6-9

National Association of Purchasing Agents—N.A.P.A.
St. Louis, Mo., May 24

National District Heating Association—N.D.H.A.
Baltimore, Md., June 28-July 1

Smoke Prevention Association—S.P.A.
Nashville, Tenn., May 17-20

Index to Topics

Power Plants and Their Operation 522
Distillery plants; Boiler design; Spare capacity

Diesel Operation and Application 523
Maintenance; Cooling systems; Speed regulation

Fuels for Steam Generation 524
Prepared fuels; Purchasing aids

Smoke Abatement and Flue Gases 525
City ordinances; Density meter; Gas scrubbing

Water Treatment 526
Carbonacious zeolite; Embrittlement studies; Carryover; Organic exchange bodies

The Diesel Is News 529
Locomotives; High speeds; Supercharging

Diesel Fuels and Lubrication 530
Standard fuels; Filtering methods; Compounded oil

Metallurgy and Welding 531
Alloys; Surface hardening; Maintenance

Research in Engineering 532
Heating studies; Steam jet; Creep

The Electrical Industry 533
Economic, social and financial problems; Rising costs; Engineering and technical developments

Power Plants and Their Operation

Power and steam requirements for Distillery; Combined hydro and steam electric system; modern boilers

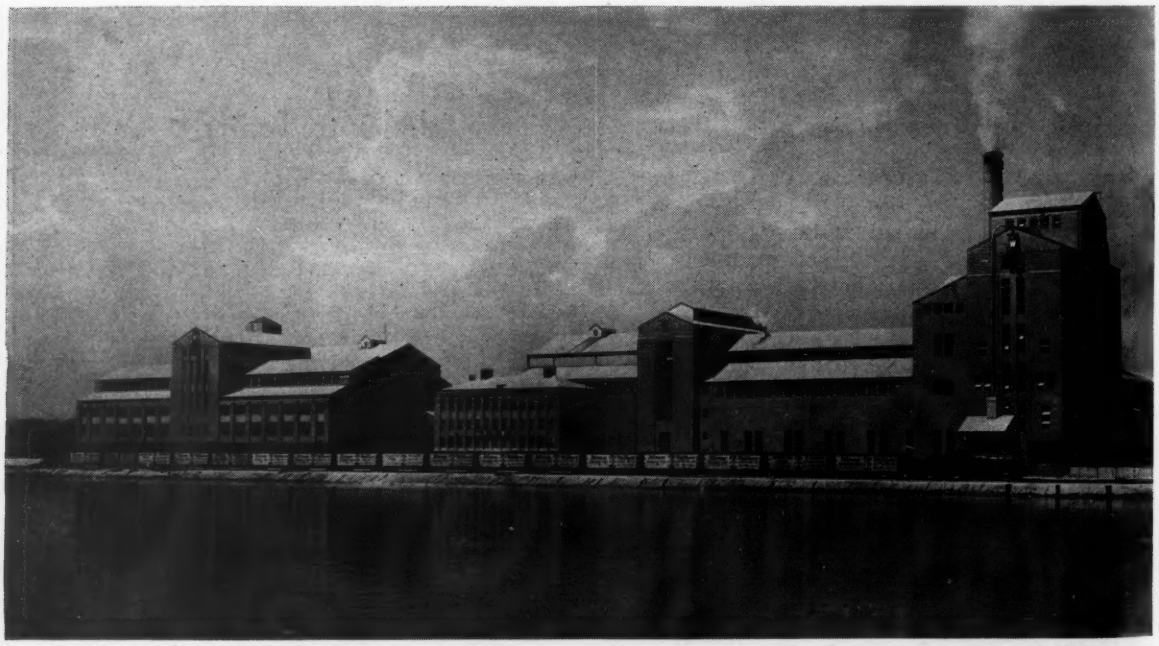
EACH YEAR brings forth so many changes in power plant practice—pressures, temperatures, flow diagrams, heat cycles, operating methods, equipment, controls, load curves—that the men in charge of operation are demanding of their societies more authentic data on all operating problems. No power plant design or piece of equipment in the plant can be considered a success until it has proved itself safe, reliable and economical in operation. Just what portion of credit should go to the designer and to the operator of a plant will always be a debatable question and "buck passing" of failures is a too common habit, certain it is, however, that detailed information on operation of power plant equipment is too scarce, particularly in industrial and institutional plants.

Many problems that do not present themselves in a utility plant are of major importance in a plant serving an industry as was brought out in a paper by Hiram L. Walton, of Smith, Hinckman & Grylls, Inc., which dealt with power plant requirements of a distillery. From the standpoint of power plant design and the factors affecting it, the Peoria and Louisville distilleries, as two modern installations, offer a decided contrast, according to Mr. Walton. Each is basically representative of the type of plant that economically meets the requirements for steam and power. They have the common objective of a balance between the steam process requirements and the exhaust steam that is produced in supplying the requirements for power. Both plants come reasonably close to meeting this objective. But the Louisville distillery is representative of a plant in which dry ice manufacture and evaporation of thin slop are not factors affecting the characteristics and capacity of its power plant.

Comparatively, the modern distillery, in its utilization of steam and electric power and in its facilities for providing these services, is an efficient and economical chemical plant. Thermally there is considerable margin between the efficiencies obtained in practice and those possible. The extent to which improvements in future distillery construction and operation will reduce this margin is largely a matter of cost of construction and equipment balanced against the cost of fuel.

Plans were described at the A.S.M.E. meeting by H. L. Harrington and E. B. Strowger for centralized supervision of power supply facilities of a combined hydro and steam electric system involving certain system changes, in order to provide satisfactory and reliable service to all customers economically.

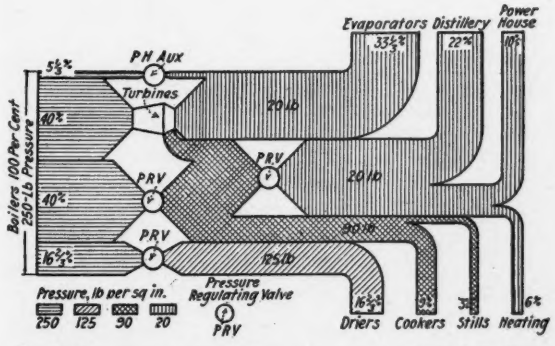
Among the modern trends in plant equipment, high capacity boilers have taken a prominent place, as was indicated by John Van Brunt of Combustion Engineering Co. in his review of development in designs leading up to modern high pressure, high



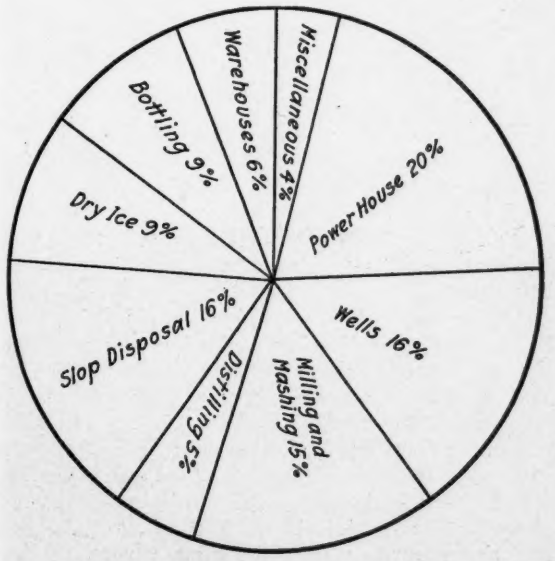
Hiram Walker Distillery Plant at Peoria, Ill., is served by a strictly modern power plant

capacity steam generating units. He showed the limitations of earlier types that render them unsuited to high capacity requirements. It is interesting to note that 82 per cent of the boilers involved in a recent survey are of the bent tube type; approximately 40 per cent were fired with pulverized coal; 43 per cent were stoker fired and 17 per cent burned oil or gas. The industrial field, unlike the utilities permits of a greater degree of standardization in design.

Problems in operation have always been treated in a thorough manner by the N.D.H.A. and this year was no exception for the Steam Station Engineering Committee presented reports of direct value on the



Distribution of steam for various purposes at a typical distillery



Electric power utilization at a typical distillery

following subjects: Elimination of overheated boiler tubes and reduction of moisture in steam at the Beacon Street heating plant; spare capacity and system economics; spare capacity allowance in operation; spare boiler capacity for district heating plant; spare capacity for steam heating system; spare capacity from the design and operating viewpoints; spare boilers in the Detroit Edison Co. heating system; a survey of steel stacks; Trinity Place stack; and tests on the scrubbing of flue gases.

Diesel Operation and Application

Research means romance and progress but the men who buy and operate engines insist on speaking in practical language of cost, performance, application and operation.

GOOD MAINTENANCE and operation are essential and it is surprising that so little has been written on the plant personnel itself, the men who are entrusted with these important functions. J. M. Drabelle of the Iowa Electric Light & Power Co. touched on this point at the M.P.C. and said that a well paid, well trained, happy group of operators with a good ear for sound and keen sense of observation was an absolute necessity for the success of a Diesel plant. This paper, printed on page 337 of the May issue, also pointed out that the maintenance cycle runs from 4 to 6 yr., with a low cost for 2 to 4 yr. after a unit is placed in service and on the 4 to 6 yr. a heavy maintenance expenditure for new parts subject to stress, friction and temperature.

Maintenance programs must be worked out to fit individual needs and should be somewhere between the "fix it when it breaks scheme" to a set routine so complex as to be of questionable value. This was outlined in a comprehensive way by E. R. Spencer, Assistant Chief Engineer of the Texas Pipe Line Co., at the Dallas Meeting. His paper, which deserves detailed study and will be reprinted later, points out the factors essential to successful maintenance regardless of the type of plant and concludes with detailed inspection reports and schedules as utilized by a large organization with many engines in scattered localities.

One of the unavoidable maintenance problems is piston ring and cylinder wear which is to a certain extent controllable by the engine designer. This is not a new problem but extends back to the early steam engine days which Harte Cooke of the American Locomotive Co. reviewed at Dallas, possibly to point out a moral. Lack of lubrication at the exact point where lubrication was needed and excessive pressure behind the ring were the main causes of trouble. Mr. Cooke knows both Diesel and steam engines backward and forward, so to a casual observer, it would appear that his detailed review of steam engine experiences was a gentle hint that a little practical common sense based on fundamental principles may sometimes be more effective in correcting difficulties than the formulation of a complicated new theory demanding extensive research for verification.

Of course satisfactory operation is predicated upon adequate cooling and Gustave J. Bischof, consulting engineer of the Cooling Tower Co., quoted results of a questionnaire showing that the cooling water must carry away from 1300 to 3500 B.t.u. per hp. hr. for Diesels and from 3500 to 5400 B.t.u. per br.hp. for gas engines. Open systems ranging from $1 to $4 per hp. are cheaper and can be used with some waters but closed systems have many advantages and usually justify the higher investment of from $3 to $11 per hp. Sometimes water loss in itself is important and may influence the actual type of cooling equipment for either system. In addition to an evaporation loss of approximately a pound of water for every 1000 B.t.u. dissipated, windage or driftage losses must be considered. In general terms and for average wind conditions this will range from 3 to 5 per cent for a spray pond, 1 to 1½ per cent for an atmospheric tower and from 1/5 and 1/2 per cent for a mechanical draft tower with a proper elimination system.

Speed regulation of Diesel engines has in the past not been entirely comparable with regulation of steam and water turbines. Of recent years the importance of this point has increased due to electric clocks and interconnected power systems. Willard J. Whitehead of the Woodward Governor Co. traced the development of the type IC governor for power generation and the type SI for variable speed service as in electric locomotives.

The Dallas meeting was quite generally attended by men with a direct or indirect interest in the oil industry where gas engines are prime favorites for pumping. W. H. Stueve of the Oklahoma Gas & Elec. Co. was on hand to ride his favorite hobby and point out that the gas engine has a serious competitor, the electric motor. His statement was well supported by data and he estimates that 35 per cent of the wells to be equipped in 1938 will use electric motors, and bring the total of electrified wells up to about 7.5 per cent.

Competition between engines and electric drive is not limited to the oil field, however, but extends across the entire industrial front. The E.E.I. at Atlantic City gave more than passing attention to the Diesel. C. W. Kellogg, president of the E.E.I. and Chairman of the Board of the Engineers Public Service Co., drew attention to the packaged Diesel units and the effect on the public of the entrance of G.M. into the small engine field.

W. H. Sammis, vice president of the Commonwealth & Southern Corp., also mentioned the G.M. Diesel but felt assured that the policies of the corporation meant fair competition which the industry does not fear. What he was primarily concerned about was the extremes in guarantees and contract terms, to which he said some companies are prepared to go, to place an initial engine plant in new territory.

As pointed out in the report of the Edison Electric Institute Convention in the July issue, the efforts of the utility men today are being directed largely against the economic problems confronting the industry. The major problem involves the decreased revenue as compared to the cost of doing business.

Fuels for Steam Generation

Prepared coals and cokes are being demanded; Coal selection charts are aid to purchaser; General knowledge on coals is lacking

AS A SOURCE of energy for industry, nothing so far has been able to supplant fuel, particularly coal. The nearest approach is falling water which has definite limitations. So it is not surprising that engineers are continually giving thought to fuel sources, improvements in the quality of the products, marketing methods and efficient utilization. It is universally recognized that all our sources of natural fuels, such as coal, oil and gas, are depleting, the estimates of the time these fuels will continue to supply our needs varying from several thousands of years for coal to less than a decade for oil and gas. It is thus with almost feverish haste scientists and engineers are endeavoring to devise methods and processes by which these supplies may be stretched out so as to leave posterity with some forms of natural fuels.

Coal being the most plentiful at the present time is being made to yield both gaseous and liquid fuels for industrial uses. These "made" fuels while not as yet economically practicable as substitutes for the natural products in all cases, are finding fields for themselves that will undoubtedly grow as the depleting supplies of natural sources change the economic balance.

On the subject of coal washing, L. C. McCabe, of the Illinois Geological Survey, has conducted investigations to determine the extent to which impurities can be economically removed. By means of washing, he reported at the A.S.M.E. meeting, dust, clays, shale and sulfur (mostly pyritic) can be removed to secure coal with a uniform ash content of not over 5 per cent thus giving a fuel that is improved in uniformity, enhanced in heat value, leaves less ash, contains less dust and sulfur to produce injurious vapors.

In the well known coke processes, heat is applied to the coal in ovens from which air is excluded. By thus gasifying and carrying away the hydrocarbons in the coal, the residue or coke becomes what is usually spoken of as a smokeless solid fuel. The quality of the coke, however, depends to a large extent on the temperature to which the coal is heated, the time of heating and the pressure carried in the oven as well as the quality of the coal used. One of the newly developed methods is the Curran-Knowles process which was described at the A.S.M.E. meeting by M. D. Curran, who stated that his process was

developed primarily to produce a fuel suitable for domestic use.

It is not only into fuel technology that engineers are delving but also in the economics of their utilization. Each type of stoker or burner, the furnace design and boiler heating surface arrangement has peculiarities which demand careful selection of coal if best results of heat transfer, ash and slag removal, absence of smoke and fly ash are to be secured. All this was brought out in an address by J. E. Tobey of Appalachian Coals, Inc., before the National Association of Purchasing Agents, in which reference was made to coal selection charts prepared by the Fuel Committee of that Association. There are seven of these charts, outlining 32 technical factors, their relative importance, and 25 use classifications affecting coal selection.

Then again, the quality of coal varies greatly from district to district and even from mine to mine and engineers have found that improvements in quality can be made by various kinds of processing, such as removing slate, washing and dedusting. These improve the burning characteristics principally by the removal of ash and clinker forming constituents, and remove some of the disadvantages of handling. For use in power boiler furnaces, further processing of coal would appear to be a long way in the future. Carbonization or coking, however, has long been done in order to secure two types of fuel, gaseous and solid.

It was stated that of the 100,000 coal burning industrial plants in the United States probably no two are surrounded by identical conditions, even though their design may be identical. Defects are almost sure to develop which have a restricting effect upon coal selection. So true is this that E. C. Payne has stated his belief that 99 out of a hundred power plants today are restricted to the burning of premium coals which do not represent the best fuel values available to produce steam at the lowest overall cost, because of some critical weakness.

That the price the consumer must pay for fuel has been going up nobody has doubted, but the Operating Statistics Committee of the N.D.H.A. reports the results of a survey in which 16 out of 24 companies questioned reported a general increase in the market price of coal. The advance in price ranged from 3.5 per cent to 29 per cent with a general net average increase of 9.8 per cent, three companies reporting decreases or no change. The upswing in the market was common to all districts excepting the southern.

The market price of black fuel oil varied considerably in different sections of the country, the greatest increase being 25 per cent with an average of 8 per cent reported by 11 companies.

No change in the price of natural gas was reported, although the cost per million B.t.u. increased in the case of companies reporting on this subject.

While the figures just given were taken from the 1937 records, the prices of coal for 1938 are undoubtedly higher due to the working of the Bituminous Coal Act of 1937, the price fixing features of which, however, have only been partially operative.

Smoke Abatement and Flue Gases

St. Louis controls quality of coal sold in city; Smoke standards needed; Fly ash and sulfur removal from gases

POLLUTION OF CITY atmosphere with smoke from power plants has long been against the law in nearly all first class cities. Even with large boiler plants strictly obeying the laws, the atmosphere in some cities is still filled with pollution from coal furnaces in domestic service, apartment houses and industrial establishments. Smoke, fly ash and sulphur gases are the offenders against which the engineers and publicists are waging war. At no time has the problem been attacked with more vigor and determination than at present. It is recognized that almost any kind of commercial fuel can be burned without producing smoke if the burning equipment is designed, constructed and operated according to the requirements of that particular fuel. This suggests three points of attack: 1. Control of the selection of burning equipment; 2. Education of those in charge of operation of combustion equipment, and 3. Control of the sale of solid fuel to consumers in the city.

City ordinances now in effect have been formulated on the first two points but it remained for St. Louis to add to its laws an ordinance controlling the quality of coal permitted to be sold in the city.

It was stated by R. R. Tucker, Commissioner of Smoke Regulation, at the A.S.M.E. meeting that considerable controversy resulted when this particular provision was proposed. The press, special interests, and some of the uninformed public claimed that this section was unnecessary; they contended that it would destroy the trade territory around St. Louis. Boycotts were even threatened by various small towns in Illinois.

The administration did not claim that this section would eliminate smoke, but it did claim that following its provisions would reduce sulfur and fly ash and produce a fuel of uniform quality with higher calorific value which would adapt itself more readily to underfeed stokers and produce a fuel with a higher fusion point of ash, thus improving the fuel bed conditions and reducing clinker trouble. Mr. Tucker stated that it was not unusual, before this law came into effect, to receive coals in this market containing as high as 30 per cent of ash and 5 to 6 per cent of sulfur. The Commission recognizes that miracles cannot be performed by legislative acts but the way can be pointed out and the final solution can be attained only through the wholehearted and continued coöperation of all concerned.

This is not the first pioneering work the City of St. Louis has done in the way of legislation governing

smoke abatement but it does appear to be the most radical and officials of other cities are following the experiment with interest. Engineers recognize, however, that the conditions in St. Louis are exceptional because the major part of its coal comes from nearby mines in Illinois the products of which are high in ash and sulfur.

As related to the industries, C. J. Colley of the Monsanto Chemical Co. expressed the opinion that the smoke problem has been substantially solved but that any further reduction in city smoke will come through the use of a smokeless fuel for the small consumer. This, it was pointed out, is a problem with which the A.S.M.E. is working.

Enforcement of smoke abatement laws has always met with difficulty because of the difference of opinion as to the smoke density, and few firemen have been provided with any means whatever of continuously indicating the exact condition of their flue gases. After carrying on experimental work for seven years, H. E. Bumgardner of the Detroit Edison Co. has developed a method of indicating and recording smoke density which he described as an answer to this problem.

It should be noted that the fight against smoke has not stopped with the enactment of laws for M. D. Curran, as previously noted, has improved the coal carbonization process; Julian R. Fellows of the University of Illinois has developed a down-draft conversion burner for installation in hand fired domestic furnaces making it possible to burn properly prepared bituminous coal without smoke; others are looking for the solution through the use of manufactured gas, as was indicated by M. H. Mawhinney, consulting engineer of Salem, Ohio, in his contribution to the A.S.M.E. on Fuels for Industrial Heating Furnaces; J. F. Barkley of the U. S. Bureau of Mines, in discussing smoke and fly ash from spreader stokers at the Smoke Prevention Association convention, expressed the opinion that with certain features properly taken care of in a conservative—not merely an optimistic manner, the spreader type stoker should meet city smoke ordinances as well as other types; also at the S.P.A. convention, Charles H. Schroeder of the Bernitz Furnace Appliance Co. devoted a paper to the features of furnace design essential to the elimination of smoke and fly ash; in all smoke abatement sessions of engineering meetings, the outstanding plea expressed time and again is for a better understanding of combustion principles by furnace attendants.

Another method of attacking the problem of fly ash and sulfur gases is by means of scrubbing the flue gases before they are discharged to the atmosphere. In this direction, Thomas Ravese and T. J. Finnegan, both of the New York Steam Corp., reported to the N.D.H.A. the results of tests they had conducted in the Burling Slip plant. It was stated that heretofore the use of water for flue gas washing has not been generally accepted because it entailed such costly maintenance problems. The development of corrosion-resisting metals and paints of various kinds has now made it possible to investigate the problem with the use of wetted agents.

It is recognized that with a sufficient water supply the removal of considerable solid matter and a limited amount of sulfur oxides may be removed from the flue gases by means of properly designed spray nozzles.

Water Treatment

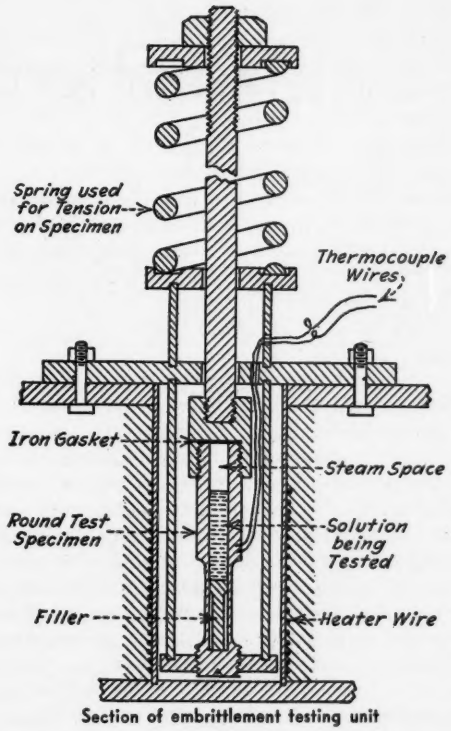
Carbonaceous zeolites enter field; New test methods for embrittling water; Deposits on steam turbine blades; Hydrolysis studies; Organic types of exchange bodies

ADVANCE in boiler pressures and temperatures have brought with them a variety of chemical conditions within the boiler that do not exist at the lower pressures and a better understanding of the effects of the impurities in boiler water on the metals used in construction and their fabrication is developing out of the various intensive studies and research that is being carried on. As reported in several papers presented at the A.S.M.E. meeting progress is definitely being made, the formation of boiler scale is definitely prevented by a number of different methods of treatment which are generally known to the profession, but, in the prevention of scale, the various chemicals used have been found to act upon the metals in different ways—corrosion or forms of embrittlement—at high temperatures and pressures, also in the formation of CO_2 gas which, when combined with the condensate forms water with an acid reaction in the steam piping system, results in destructive corrosion of piping. Problems of this sort, highly technical in the chemical science, are those being studied and reported upon at sessions of engineering meetings.

Being announced and treated technically before an engineering meeting for the first time, carbonaceous zeolites attracted an unusual amount of interest. Howard L. Tiger of the Permutit Co. who presented the paper explained that the usual sodium zeolites hitherto known, which exchange their sodium base for calcium and magnesium (hardness), reduce this hardness to a minimum, but do not reduce total solids or alkalinity. The new hydrogen zeolites retain the simplicity and complete hardness-removal characteristics of zeolite softeners and at the same time eliminate the alkalinity with a corresponding reduction in total solids and CO_2 content of steam, and an increase in the sulphate-carbonate ratio. Furthermore, he stated, they remove alkalinity present in any form; thus, for the first time in history it is possible, by simple economical means, to remove sodium alkalinity often found in raw waters.

Hydrogen zeolites, as they are called, are regenerated by dilute acid solutions in the same manner as are sodium zeolites by salt solution. By combining the hydrogen—and sodium—zeolite effluents in correct proportions, or by alkali neutralization, it is a simple matter to obtain a feedwater completely free from hardness and of any predetermined desired alkalinity.

Being made from carbonaceous substances, these hydrogen zeolites are practically free from silica. They can also be regenerated with common salt, and with such regeneration they can function in the usual sodium-zeolite cycle. Being extremely resistant to low pH (acid) waters and practically free from silica, and of



Section of embrittlement testing unit

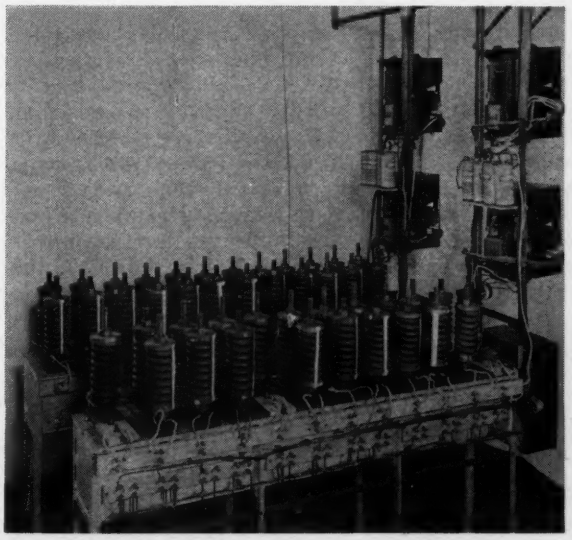
relatively high capacity, they also possess advantages when used in the usual sodium-zeolite cycle, especially where it is desired to avoid any increase in silica content, a condition that is gaining favor rapidly in the high pressure boiler field.

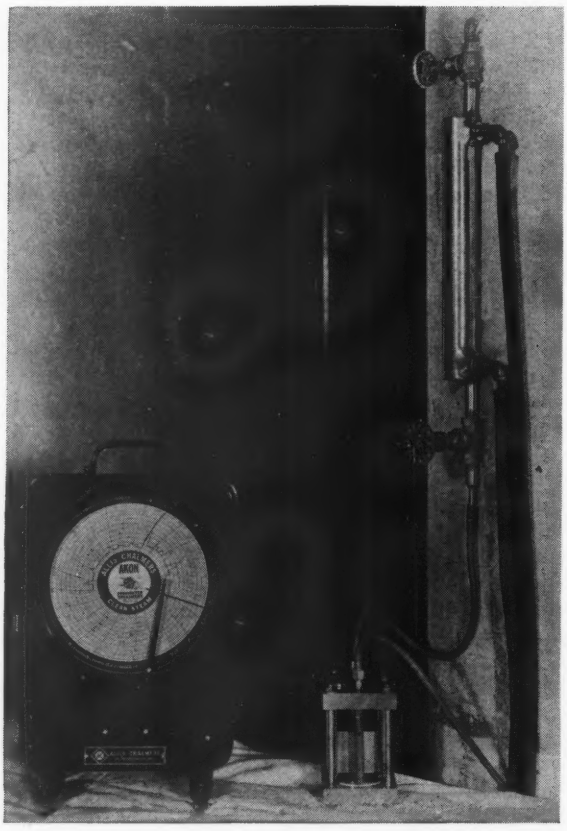
Introduced under the trade name Zeo-Karb, carbonaceous zeolite is a blackish granular material which can be prepared by any one of a variety of treatments of various carbonaceous materials such as coal, lignite or wood. The raw material, properly graded, is treated for extended periods with any one of a variety of chemicals such as fuming sulfuric acid, sulfur trioxide (SO_3), chlorosulfuric acid, or zinc chloride after which it is washed, stabilized as required, and finally screened to the desired grain size.

Least understood of all the failures of boiler metals is that due to embrittlement—a form of crystalization which manifests itself in such places as riveted areas, at tube ends and other areas where stress concentrations might occur along with capillary spaces. Failures of this type have predominated in the riveted areas, although cracking has occurred in the tube ends and the tube ligaments of the drum. As these facts were found out and demonstrated through many years of research, the causes have been studied from every conceivable angle and these studies have resulted not only in changes in boiler water treatment but also, and probably more important, changes in boiler construction. It was reported by F. G. Straub, who was the pioneer and persistent investigator of this subject, and his associate at the University of Illinois, T. A. Bradbury, that the manufacture of forged and welded drums has eliminated the riveted areas and potential danger of embrittlement in these areas; the possibility, however, of cracks occurring in the tube ends and the metal adjacent to the rolled tube ends still remains.

With all these conditions in mind, the authors designed a small test unit and devised a test method by means of which small samples of actual boiler water may be tested in tubes of actual boiler metal under applied stresses and temperatures to the point of destruction of the metal. With this equipment very definite results are being secured and, with an accumulation of test data, it should be possible to make satisfactory recommendation of boiler water treatment. It has now been determined that for steam pressures up to 250 lb. per sq. in. embrittlement can be prevented by maintaining the sodium chloride content of the boiler water greater than 0.6 times the total alkalinity, expressed as sodium carbonate, along with the sodium-sulfate content greater than 1.0 times the total alkalinity. For pressures between 500 and 1400 lb. per sq. in., embrittlement is not prevented by the maintenance of the present recommended A.S.M.E. ratios. The presence of a soluble R_2O_3 content greater than 0.6 times the SiO_2 content of the boiler water appears to prevent embrittlement at these pressures. For a steam pressure of 350 lb. per sq. in. the ratios of sulfate and chloride to alkalinity as well as the R_2O_3—SiO_2 ratio both appear to be effective in preventing embrittlement, although larger quantities may be necessary than at lower or higher pressures.

Treatment of feedwater and boiler water are old practices in power plant operation, although new processes are continuously being devised, the next step in the cycle, however, that of purifying the steam for the particular use to which it will be put, has not received the careful consideration which it deserves, nor what will be demanded as industrial progress is made. It is perfectly natural for engineers to attack first the problems which deal with the most dangerous, uneconomical and troublesome conditions, and these, in the main, have been in the evaporating unit of the steam cycle. Steam separators, steam purifiers, steam washers and other similar equipment have been devised to put the finishing touch, so to speak, on steam as it comes from the boiler. Theoretically this steam should not


Battery of embrittlement testing units in use at the University of Illinois



Conductivity meter used by S. E. Tray for measuring steam quality

need treatment of this sort, that it does is an indictment, usually, against the water treatment employed, the design of the boiler or the operating conditions to which it is subjected.

Now comes S. E. Tray of the Allis Chalmers Manufacturing Co. with reports of investigations he has been conducting on deposit of scale on the blades of steam turbines. This trouble, he indicates, is practically universal in spite of all the precautions now being taken to avert it, yet there is an appalling lack of information that can be used to correct the condition in the field.

Priming, foaming and carryover are recognized as the usual conditions that contaminate the steam with scale forming impurities and it is to avert these that the boiler operator must direct his attention if the steam turbine in his plant is to be operated economically and continuously for long periods of time. And who knows but that in the well equipped plant of the future the operator will have another instrument known as the conductivity meter for measuring steam quality to guide him in the path of least trouble?

The investigations reported indicate that sodium hydroxide and silica carried over from the boiler water are responsible for the majority of turbine deposits. Sodium hydroxide, said Mr. Tray, cannot be eliminated from boiler water as a sufficient quantity must be present to keep the pH value of the boiler water in the range between 10.5 and 10.8 to prevent corrosion. The quantity of soluble silica that can be safely carried in the boiler is thus far only a matter of observation.

Problems of strength of materials used in the construction of boilers for generation of steam at high pressure and high temperature are not by any means the only ones that differ from those for lower operating conditions, as was pointed out by R. M. Hitchens, of the Monsanto Chemical Co., and J. W. Purssell, of the Boston Edison Co., who have been investigating the behavior of sodium sulfite in high pressure steam boilers. Sodium sulfite is used extensively as a final step in the dioxygenation of boiler water and as insurance of zero oxygen content in such waters, this has given rise to considerable discussion, first as to its efficacy and second as to its freedom from damaging side reactions.

Controversies have arisen over the possibility that it might undergo hydrolysis at boiler temperatures to form sodium hydroxide and sulfur dioxide, the latter being carried into the steam as a gas. Following investigation, the authors report that it is rather doubtful if such a reaction occurs to any measurable extent. Another controversial question concerns the possible decomposition of sodium sulfite solutions at elevated temperatures. It is known that at a red heat solid sodium sulfite undergoes auto-oxidation and reduction to sodium sulfate and sodium sulfide. It is now reported that laboratory experiments indicate no such decomposition of a 1 per cent solution of sodium sulfite at steam temperatures of 490 deg. F. (600 lb. pressure). Decomposition, however, does occur in the presence of cupric or cuprous oxide. Iron oxide promotes the same reaction slowly. As a result of their findings, the authors see no objection to the use of sodium sulfite for oxygen removal in high pressure boilers. Continuous feeding to maintain 10 to 20 p.p.m. of sodium sulfite in the boiler water is indicated.

Coming to the more common problem of boiler operation, the Steam Station Engineering Committee of the N.D.H.A. has been investigating what improvements can be made in boiler design and operation to eliminate moisture in steam in a particular installation of a three-drum bent tube boiler. The investigation was initiated through the overheating of the top row of water circulating tubes. Raising the water level in the boiler to correct the overheating resulted in wet steam. The final solution was a double perforated baffle in the front steam drum, the addition of three new rows of steam circulating tubes making four rows total and carrying the water at a higher level.

P. G. Bird, of National Aluminate Corp., discussed before the A.S.T.M., the new organic types of exchange bodies as applied to water treatment for the complete or partial removal of dissolved salts, this use of exchange filters being a relatively new practice. To effect practically complete removal of dissolved salts from water, the water is passed through two filter beds arranged in series. The first bed, known as the "cation exchanger bed," removes the positive ions, or cations such as those of calcium, magnesium, and sodium. The second bed removes the negative ions, or anions, such as the chlorides, sulfates, and nitrates and is referred to as an "anion exchanger bed." The carbonate ions, or CO_2, which enter the system as bound CO_2 in the carbonates and bicarbonates of the raw water are not removed in either bed, but are released by aeration after the water has passed through the system.

The Diesel Is News

Time devoted to the Diesel at engineering conventions prove an ever widening interest. High speed holds the limelight and occupies research departments but the operator and user do not forget the slower speed units are still doing most of the work in the stationary fields.

HIGH SPEED has a modern streamlined tang that never fails to catch the interest of the general public, and, in a slightly different color scheme, garnished with a few figures, seems to be equally effective on engineers. Due to the romance of railroading, the spectacular rise of light weight Diesel propelled trains forms an interesting spot on any convention program. No one can present this subject better than E. F. Webber, Superintendent of Automotive Equipment of the Burlington Lines.

Eight Zephyrs now account for 13.5 per cent of the total passenger train mileage of the entire system and he has no hesitation in saying that ultimately all passenger trains will be propelled by Diesel engines. This may seem a little strong in the light of steam train activities on other lines but one must remember that Mr. Webber speaks from first hand knowledge and experience and can back his opinions with comparative operating data.

Overall efficiencies from fuel to rail reach the almost unbelievable figure of 27.5 per cent, which may be tinged a bit with theoretical assumptions, but is nevertheless backed by dynanometer tests and road service. The 3000-hp. Zephyrs have a fuel cost of $169.69 per round trip of 2073 mi. between Denver and Chicago compared with a fuel and water cost of $419.53 for a steam locomotive handling a standard train, or $326.32 for a steam locomotive on a light weight train.

Increased speeds have necessitated wholesale changes in the track, signal systems and operating clearance times and as pointed out by F. H. Prescott of the Electro Motive Corp. before the Midwest Power Conference, has intensified the problem of braking During discussion it was brought out that one road is experimenting with a new type disc brake which, it is rumored, will stop a train going 90 mi. per hr. in 1500 ft. A 3600 hp. Diesel locomotive made up of two 1800 hp. units has about the same work rating as a Hudson type steam locomotive, but 3600 hp. is not the limit by any means and two 5400 hp. triple units have been in service for some time.

High speed engine operation is, however, the treasure which Diesel engineers throughout the world are seeking at the foot of the rainbow, a treasure of promises in lighter weight, lower costs and a more extensive field of application. Back of romance the hunt has already caused many heartbreaks and disappointments but the hard work has already produced practical results.

The automotive field is a promising one for the smaller units. At the S.A.F. Summer Meeting, P. M. Heldt of Automatic Industries gave data on a number of European engines ranging in speed up to 3500 r.p.m. Of 176 of these engines 55 were for direct injection, 53 had precombustion chambers, 49 turbulence chambers, and 19 air chambers. The vast majority are for four cycle operation although the two cycle engine appears to be in the ascendancy with much development work under way particularly in the aviation field.

Speaking from a background of 20 yr. in the high speed field, C. L. Cummins, president of the Cummins Engine Co., said that progress so far indicates still higher speed, lighter weight and greater flexibility will be demanded in the future and that the ultimate limit is not yet in sight. This limit will be from the direct injection engine, however, for he feels that the time lag involved with the precombustion type is too much of a handicap to be overcome.

Merely stamping a higher rating on the name plate naturally will not result in a satisfactorily performing high-speed engine. As the r.p.m. goes up, the pressures invariably go up with it, torsional vibration creeps in, inertia forces become more serious, the problem of getting rid of the additional heat involved in working the parts oftener becomes serious, volumetric efficiency has to be looked into, in fact, the entire engine must go through a complete change. Therefore, most of the developments today in connection with high-speed engines are along some of these lines.

At the Dallas meeting of the A.S.M.E. a number of companies, notably Chicago Pneumatic, Fairbanks-Morse, and National Supply, announced new designs in the present so-called high speed range for larger units. Two of these were for 720 r.p.m. although one was designed for a contemplated maximum of 900 r.p.m. During the year the announcement was made by General motors New Diesel set-up based on a high degree of standardization and produced in quantities in typical automotive style (see p. 144 of the February issue). Motion pictures of the production set up of the smaller sizes at Detroit were shown at the Dallas meeting and served as a forceful reminder that the small Diesel in large quantities is a commercial factor and can no longer be regarded as in the experimental stage.

Supercharging which in this country has lagged somewhat, is being taken more seriously and is usually represented at least once on most engine programs. Practical aspects of superchanging were discussed at length by Harte Cooke, of American Locomotive, before the Detroit meeting of the S. A. E. (see p. 369 of the June, 1938, issue) and from the standpoint of engine design by Russell Pyles of Clark Bros. before the White Sulphur Springs meeting. Listing means available for improved performance as, increased engine speed, increased m.e.p., two cycle operation and supercharging, he felt that the last offered a means of increasing the specific output of the Diesel with a minimum of disadvantage and new problems.

It can readiy be applied to existing conservative engine designs to raise the brake horsepower approximately 50 per cent. Except where space is at a decided premium as in railroad service, this increased rating will probably have little commercial application for some time to come. Probably the new CP 800 hp. engine installed by the Northwestern Light & Power Co. with a separately driven Roots blower to increase the peak capacity to 1000 hp. net will be closer to the usual commercial figure.

Diesel Fuels and Lubrication

Two factors vital to the development of the high speed engine, which are the objects of intensive research

DIESEL FUELS present a many sided problem which involves the refiner, designer and operator. Production is, of course, tied up with the primary problem of gasoline production while use is complicated by a variety of engine designs which react differently to different fuels. The day of the old time engine that would burn anything is definitely past and designers are to an increasing extent specifying limits of various oil properties.

A definite start toward standardization has been made by the Bureau of Standards and A.S.T.M. but these standards have not as yet received wide commercial use and probably will not until the mechanics of combustion and the true significance of the many factors are more thoroughly understood.

Combustion itself is being investigated intensively both for compression ignition and spark ignition engines. Knock, common to both types due to a sudden and intense pressure rise during the combustion process, is influenced by different factors in each case and must be corrected in different ways. Dopes which correct knock in a spark ignition engine aggravate it in a Diesel so that the common octane rating of gasoline is paralleled by a cetane number for fuel oil.

Research has shown that combustion takes place in three stages: first, a delay period which is partially chemical and partially physical during which the fuel injected is heated up to the ignition point; second, rapid burning of the fuel injected during the delay period; and third, rapid ignition of the balance of the fuel as it is injected from the spray valve into the burning gases.

Work on the delay period has been held up somewhat by the development of a test which would be reproducible and yet be a measure of the ignition quality. Although there is said to be less deviation between laboratory and service tests with cetane numbers, than between laboratory and service tests of octane numbers of gasoline, the work started several years ago by the Volunteer Group of Compression Ignition Fuel Research is far from finished. The object of this work is not to eliminate the delay period but to control it and provide a definite measure so that the proper fuel for a given engine can be specified.

At the Dallas A.S.M.E. meeting, G. L. Stetson, Senior Research Engineer of the Diesel Engine Div. of Shell Petroleum, said that work is now being done or needed in order to supply a digestible diet to the average medium and high speed engine of the future include: Filtering methods to avoid wax troubles at low temperatures; measurement of cetane numbers and further consideration of its significance; a suitable test for determining the volatility of blended Diesel oils and investigation of the significance of this factor in incomplete combustion as well as in fuel nozzle and piston ring deposits.

Deposits on the working parts come of course from both fuel and lubricating oils and the former has been the subject of extensive investigation by J. R. Mac Gregor and W. V. Hanley of the Standard Oil of Cal. Results, presented before the S.A.E. and abstracted elsewhere in this issue, show a promising correlation between service tests and certain physical properties, but the final conclusion is that the designer is the most important factor in the control.

Addition agents have done much to improve the deficiencies of straight mineral oils. This development was considered from the standpoint of tractor motors by C. M. Larson of Sinclair at the Milwaukee S.A.E. Meeting, and more generally by Messrs. Bray, Moore and Merrill of the Union oil at the S.A.E. summer meeting.

Several brands of compounded oil are now available to Diesel engine operators and the properties exhibited by the soap-compounded groups include: detergency, which aids in preventing ring sticking; high film strength, which reduces the danger of scuffing, scratching, or galling under adverse or severe conditions; high degree of oiliness, which reduces wear under normal operating conditions; low carbon-forming tendency; and, adequate crankcase stability, which promotes cleanliness of the engine and continuance of efficient lubrication.

According to their experience, none of the soap-type addition agents found in the oils being marketed at the present time are appreciably corrosive to babbitt under the temperatures prevailing, but all of these addition agents are definitely corrosive to cadmium-silver, copperload, and other alloy type connecting rod and main bearings. Consequently it has been necessary to restrict the use of the soap-type compounded Diesel engine lubricating oil to those engines using only babbitt connecting rod and main bearings.

It is obvious that before the full degree of utility can be realized with the compounded Diesel engine lubricating oils, they must be made noncorrosive to the newer bearing alloys which appear to be necessary under high speed, high temperature conditions. Consequently it is expected to be only a matter of time until an all-purpose, noncorrosive compounded oil will be available to Diesel engine operators.

Soaps found currently in Diesel engine lubricating oils manufactured in this country include aluminum naphthenate (which has been used in castor machine oils for a relatively long period of time), calcium naphthenate, calcium oleate, calcium phenyl stearate, and calcium dichlorostearate.

Metallurgy and Welding

Extravagant use of metals deplored; Surface hardening; Welding in maintenance; Cost of welding

WHEN the landscape artist wishes to use paint that will match a specific color he sees in forest, field or sky he has primary colors from which to select and by blending the correct colors in proper portions the exact match is secured. It is the dream of the engineer that some such procedure may be worked out for the selection of metals he wishes to use in the design of his machines and appliances. Metallurgists have gone a long way in this direction but each year brings forth new metals, speaking more exactly, perhaps the proper term would be new combinations of metals, with an entirely new combination of qualities—specific gravity, strength, hardness, ductility, conductivity, melting point, resistivity to corrosion and erosion—which fulfill specific needs in industrial design. There seems to be no end to the selections that can be made which means no end to the research necessary to classify these new materials.

Delivered as the Calvan W. Rice lecture at the A.S.M.E. meeting by T. H. Wickenden, a paper on the subject "Some Contributions of Metallurgy to Engineering Progress," prepared by William R. Barcley, metallurgist for the Mond Nickel Co., Ltd. of London, England, set forth this eminent scientist's philosophy of the engineer's responsibility to the society in the use of metals available for industrial purposes.

He warned that the world cannot afford to continue the present extravagant use of its metals and deplored the waste of metal resources. He presented new possibilities of conservation without a reduction in the use of metals, his solution being economy through the development of new longer-life metals and alloys. Some of the most promising developments, he said, lie in the new nickel-aluminum-cobalt combinations. These new alloys have been used with great effectiveness in the manufacture of magnets. A magnet made of this material can do ten times the work of one made out of other commonly used metals. These magnets can lift sixty times their own weight.

Some of the new magnesium alloys are ultra-light but have the strength of wrought iron, and are going into the new airplanes; in fact, are making them possible. Ten years ago, not more than 20 tons of these alloys were produced annually in England. Now production is exceeding 3000 tons a year.

Another new metal resists heat and corrosion to a remarkable degree. Turbines in which it has been used have run for 26,000 hr. without stopping, with 22,000 of the hours at a temperature of 1000 deg. F.

The metallurgists have solved many difficult problems by the development of powdering processes. Melting tungsten, which fuses only at 5400 deg. F., has never been possible on a commercial scale. Scientists, however, have found that if the tungsten is powdered and subjected to heavy pressure at a relatively low heat, it will weld together in a solid mass. It then can be drawn out into filaments for electric-light bulbs and other uses.

"We live today," he said, "in a period in which we are trying paradoxically to combine high standards of living with super-extravagant expenditures in armaments which essentially mean waste."

That engineers are applying just that kind of philosophy in the use of metals is evidenced by the oxyacetylene surface hardening process which was discussed by A. K. Seemann of the Linde Air Products Co. In this process, the surface of a quench-hardening ferrous material is raised to the critical temperature and quenched. The chemical composition of the steel is unaltered.

Maintenance engineers are lengthening the life of the metals used in the construction of the machinery under their care by making repairs of broken parts and building up worn members through the art of welding. Each individual has his preference as to the type of welding equipment to employ, whether gas, electrical or thermit, but the discussion of this subject at the A.S.M.E. meeting presented by H. R. Wass of Bonne Terre, Mo., was confined to work done by the electric metallic-arc and oxyacetylene processes.

In general, the processes and practices appear well-established; based upon 1920 or even 1930 standards of practice, these methods have enabled the engineer to accomplish so much in the way of simplifying and improving his maintenance methods, reducing his repair costs, and fortifying his operating equipment for longer operating periods between major overhaul outages that no engineer can afford to overlook the opportunities which are virtually thrust into his line of vision by the use of these processes.

It was to the cost of welding and welded products that E. W. P. Smith of the Lincoln Electric Co. drew attention at the A.S.M.E. meeting. Welding cost, he stated, is made up of three general parts—labor, electrode and power. Each of these factors were dealt with in detail with suggestions as to how their costs may be kept at a minimum for the usual types of joints used in construction work.

Interest in the cost of pipe welding was also indicated in the report of the distribution committee of the N.D.H.A., where the item of pipe welds was listed in the cost of a 12-in. steam line and manholes problem considered for a hypothetical city block. It is interesting to note that this pipe welding job is estimated to cost most at Boston at $480, next at Detroit at $437 and lowest at Lansing at $209.

Research in Engineering

Studies in heating field; Steam jet refrigeration; Steam line and manhole design; Mathematical formulas applied.

CAREFUL and critical examination in seeking facts and principles is a dictionary definition of the word research and what better could describe the painstaking work that engineering societies are sponsoring? Much of the results of research conducted by individuals or private corporations are made known to the profession through engineering societies as a contribution to society. Other projects are undertaken by specially chosen committees of a society; or several societies with common needs may join their resources in furthering some investigation; or again, some societies join forces with government bureaus or public educational institutions to gather facts and formulate principles needed by the profession. Whatever the method employed, members of the societies examine with extreme care every statement made by investigators for they realize that the reputation of the society hinges directly upon the correctness of the information put out under its name.

With a few exceptions, it may be said that nearly all papers presented before the technical sessions of societies are the results of research but in this particular instance attention will be directed to the work being carried on to determine theoretical principles rather than the practical application of these principles. With this in mind, outstanding work along research lines has been done by the A.S.H.V.E. as reported at its meeting in Hot Springs, Va. Here are some of the subjects, directly in the field of power engineers in charge of heating equipment, and briefly stated purposes of the investigations: The Flow of Air Through Exhaust Grilles, by A. M. Greene, Jr., Dean of the Department of Mechanical Engineering, Princeton University and M. H. Dean, engineer, Kansas City, Mo. Detailing an investigation to determine coefficients to be used in calculating the air flow through an exhaust grille of modern form in which the work of previous investigators was checked and an improved method demonstrated.

Heat Transfer Through Single and Double Glazing by M. L. Carr, Director, Pittsburgh Testing Laboratory, R. A. Miller, technical sales engineer, Pittsburgh Plate Glass Co. and Leighton Orr, research engineer, A.S.H.V.E. Research Laboratory. Conclusions: that double glazing reduces heat losses materially; that increasing the space between the lights up to 3/8 in. shows a rapid decrease in the rate of heat transfer; that double glazing results in higher indoor glass surface temperatures as indicated by the absence of moisture or frost formation.

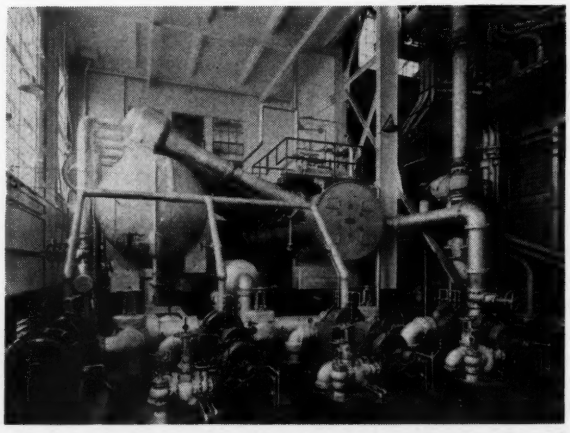
Cooling Requirements for Summer Comfort Air Conditioning in Toronto, by C. Tasker, Research Fellow, Onatrio Research Foundation. Detailing tests covering comfort reactions to summer air conditioning according to range of effective temperatures. Conclusions: That young men are comfortable at from 69½ to 72½ deg. E. T., whereas young women are comfortable through a wider range and are not unduly warm at effective temperatures up to 73½ deg. E. T.

General Reactions of 274 Office Workers to Summer Cooling and Air Conditioning, by F. C. Houghten, A. B. Newton, R. W. Qualley, co-authors of preceeding paper, and Edward Witkowski, student assistant, A.S.H.V.E. Research Laboratory. This paper showed a predominate conviction that air conditioning was beneficial in the estimation of the subjects tested, some 70 per cent of whom indicated definite advantages, such as less fatigue, better efficiency and more energy.

The procedure followed by the N.D.H.A. is to place the reporting of research work in the hands of a committee which, this year, reported tests on an 840-ton steam jet refrigeration unit, test and operating data on steam jet air conditioning equipment, steam jet coolers with evaporative condensers, and corrosion of steel smoke stacks.

The 840-ton steam jet unit tested is an interesting example of a mixed pressure machine using both live and exhaust steam, a combination which should have many applications where power is generated throughout the year. The unit tested is installed in the Los Angeles plant of the Firestone Tire and Rubber Co. and is used for process cooling.

It was reported by the committee that despite the admitted value of steam jet refrigeration as the greatest means of increasing annual load factor, this phase of district steam service is still comparatively



Steam jet refrigeration unit of 840 ton capacity, subject of research by N. D. H. A. Photo, courtesy Foster Wheeler Corp.

unknown among the member companies. A survey of over 25 member companies, shows that only two, in addition to the New York Steam Corp., have steam jet machines in their mains. The steam jet in New York City competes successfully with other types of refrigeration in spite of a high water cost.

Along a more practical line of investigation, the Distribution Committee of the N.D.H.A. presented a report on the design of a 12-in. steam line and manholes. This supplements data presented last year and now makes available material on all nine design problems which were submitted. These hypothetical design problems were worked out in extreme detail and serve as patterns for engineers confronted with similar problems.

Using the Queen of Science, mathematics, to analyze present theories of automatic control, Albert F. Spitzglass, consulting engineer of Chicago, in a paper before the A.S.M.E., compared various present methods of quantitative analysis of continuous process regulation. The fundamental considerations underlying process analysis and the simplifying assumptions necessary to facilitate mathematical approach were investigated. The equations of the regulator were defined and then combined with those for the process. This investigation was prompted by the fact that although automatic regulators have been applied successfully to a wide variety of industrial processes, the fundamental theory of regulation has not been developed to the stage where it is either consistent or easily applied to a specific case.

Last year the A.S.M.E. was presented with formulas for calculating stresses in bolted flange connections which have since been applied, the results being given in a paper by J. D. Mattimore, N. O. Smith-Petersen and H. C. Bell, all of the Walworth Co. Complete details and a numerical example were given as to how these formulas were applied to the design of the flange on a valve bonnet joint. The adjustments required to be made in the formulas for fluid pressure conditions were also given as well as a comparison of bonnet-flange designs with standard flanges.

The Joint Research Committee on Effect of Temperature of the A.S.T.M. presented a rather voluminous report outlining results of numerous investigations it is carrying on. One of the projects which should be of much value to all those concerned with the effect of temperature on metals at high temperatures is the volume on creep data which is soon to be published. This gives extensive information and data developed by the committee covering a wide range of carbon and alloy steels, irons and some non-ferrous metals.

Work on creep test of tubular members subjected to internal pressure indicated that under certain conditions a pressure vessel may decrease in length during service and under other conditions may increase in length substantially at the same rate as the diameter increases.

A final report on long-time creep tests of a 0.35 per cent carbon steel involving a test duration of 22,438 hr. indicated that the extrapalation from the 2000 hr. period was conservative as compared with actual deformation over 20,000 hr.

The Electrical Industry

Economic, social and financial problems loom; Industry advanced through engineering; Accounting costs rise; Study of utilization voltage under way; Fluorescent lamps revolutionize lighting.

THE DEVELOPMENT of the electric utility industry to its present huge proportions whether as to capital invested or installed capacity or the number of customers served has required the solution of problems of a widely diversified nature. The extent of this diversity is easily apparent from a consideration of the character of the discussion and papers presented at the various conventions of the different branches or divisions of the industry. In its broad aspects we have on the one hand the economic, social and financial problems and on the other the research and engineering problems. In certain divisions of the industry these problems are widely separated; in others they are closely interrelated. All of them are of fundamental importance and necessary to success, but as pointed out by C. W. Kellogg, president of the Edison Electric Institute before the meeting of the E.E.I. Engineering Committees held in Chicago in May, it should never be forgotten that the industry from its inception has been and continues to be basically an engineering enterprise.

Engineering furnishes the raw material the industry has to sell; it determines the quality of that raw material, how far and how successfully it can be distributed and the price at which it can be sold. Until the engineer has performed his function in respect to electric service, the other great problems are merely academic. Indeed, if all the past problems of the industry had been met as successfully as the engineering ones, the history of the electric industry would have been less troubled than it has.

The great diffusion of electricity as pointed out by C. W. Kellogg at the Chicago meeting, would have been quite impractical without the development of high tension transmission. The great extension both in number of customers and in energy consumption per customer were based upon two great and fundamental engineering accomplishments, the reduction from 4.4 to 1.4 in the pounds of coal required to produce a kilowatt hour (the latter figure at its best is now down to .8 or .9 lb.) and the intensive work of the manufacturers in the design and improvement of electricity-consuming devices.

As a consequence of this great diffusion in the use of electricity, has come a greater consciousness of its

importance by the people as a whole and social implications which could scarcely have been foreseen by the pioneers of the industry. It was inevitable that a commodity so universally useful and so valuable in contributing to the welfare, comfort and convenience of the people, should become of social and political significance. Also it was inevitable that an industry so valuable and so necessary should at times have become the object of financial manipulations good and bad and in the end, of government supervision and regulation.

It is against this background of the industry's history and growth that all present day discussion of the industry's problems should be projected. Whatever may have been the object of those who pioneerd in this great field, personal profit, the spirit of achievement or service or other personal motives, today there can be only one legitimate purpose of the industry and that purpose must have as its main objective, the greatest good for the greatest number but consistent always with the spirit of fairness and honesty.

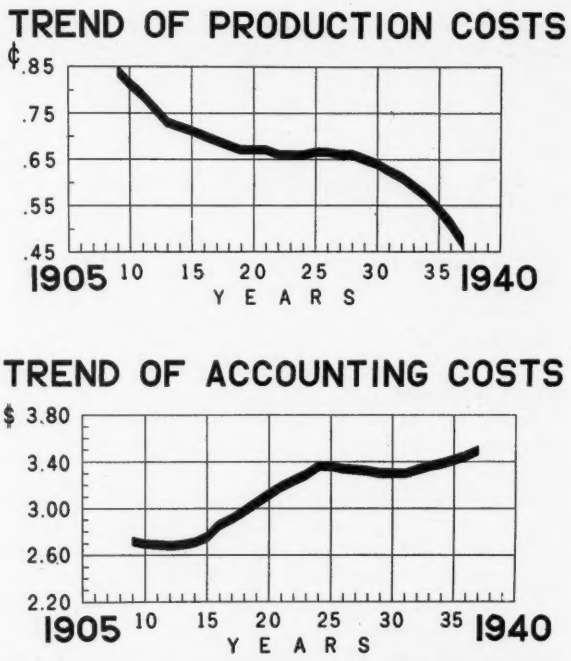
During the past six years—the years since the formation of the Edison Electric Institute out of the old National Electric Light Association—the utility men have been concerned largely in solving the extra-engineering problems confronting the industry. These problems are the most difficult of solution. Engineering problems exist, of course, but where these engineering problems are not subject to social and political forces, they can be tackled in a strictly scientific fashion. These engineering problems are handled by the engineering groups whose activities in the main are separated from the executive and financial divisions but as pointed out above, fundamentally the success of the industry rests upon the soundness of the engineering foundation.

In the utility industry as in other fields the law of diminishing returns is operative. Although actual generating costs have decreased remarkably during the past 25 yr. the distribution and accounting costs, not to mention taxes, have increased enormously. The factors involved in maintaining an adequate profit level were discussed in a number of papers at the E.E.I. Convention at Atlantic City—"Power Sales and Profits," by W. H. Sammis; "Deflecting the Curve of Rising Accounting Costs," by B. S. Rodey; "Building the Future in Residential Sales," by Davis De Bard.

Rising Accounting and Distribution Costs

The increased costs of accounting has been the subject of discussion of many recent E.E.I. meetings and is rather serious. Accounting costs have increased from $2.70 per customer per year in 1909 to approximately $3.50 in 1937—a 30 per cent increase. Production costs of electricity on the other hand have decreased from 85c per customer to 45c. In terms of production costs of electricity, accounting costs have increased in 30 yr. some 250 per cent.

A similar increase in cost is taking place with respect to distribution. As indicated by A. H. Kehoe in his paper "Cost of Plant" at the Atlantic City E.E.I. meeting, average distribution system costs per kw. of generating capacity have increased from $57 in 1920 to $89 in 1937. While these figures are somewhat startling, Mr. Kehoe was optimistic in his analysis of



The rising trend of accounting costs compared to the decreasing trend of production costs was discussed at the E.E.I. Atlantic City meeting

the situation and was inclined to think that this great increase was not necessarily indicative of a continued future increase. The high costs he pointed out had been brought about by a combination of a period of rapid growth in number of customers coupled with increased demands by both existing and new customers.

The whole question of growth in the utility industry was clearly presented by Harry A. Snow, also at the Atlantic City Convention. In this paper as well as in Mr. De Bard's paper on the future in residential sales, the importance of the residential load was clearly indicated. While still only a small proportion of the total utility load, only 19.4 per cent this class of service has increased 12 fold in the last two decades compared to only a 4 fold increase in the commercial and industrial classes respectively. As a matter of fact, the significance of the steadily growing residential load was one of the most discussed topics at the Atlantic City meeting. Once a necessary evil, it may yet become the mainstay of the utilities source of revenue.

It will be evident then from this discussion so far, that these questions of growth and increment costs, power sales, accounting, etc., are factors of vital importance to the utility executives today and that they should occupy a large part of their discussions at meetings and conventions. While government policies and practices are still a source of irritation and concern, there seems to be less apprehension over these matters now than there was two years ago. As pointed out by E.E.I. president, Kellogg, the attitude of the Securities Exchange Commission implies fairness and the conferences between the utility executives and the S.E.C. suggested by Chairman Douglas of the S.E.C. portend better coöperation.

So much for the extra-engineering aspects of the utility business. Coming now to the more technical considerations, we find that the problems confronting the industry lies in two broad divisions, one concerned with system operation and the other with electrical equipment. Questions of system operation lie more specifically with engineers associated with the utility companies and properly form the main topics of discussion at the meeting of the technical committees of the Edison Electric Institute.

Engineering and Technical Considerations

Development of electrical equipment, its manufacture, theory of operation, and operation forms the broad topic of discussion of the members of the American Institute of Electrical Engineers who have just had their spring meeting in Washington, D. C., and who are holding their Pacific Coast Convention at Portland, Oregon, this month. Naturally the range of material covered by the A.I.E.E. is extremely wide and may extend from system operation on the one hand to the details of engineering courses in colleges. The latter subject as a matter of fact has been much discussed at various meetings during the past few years.

Among the more important questions confronting those responsible for the distribution of electricity is that of utilization voltage. This problem of customers service voltage is one of long standing, in fact it goes back to the beginning. There is no longer any question in this country between 115 v. or 230 v. for lamps, and motor voltages are 110, 220 or 440 rather than some odd voltages. It is difficult, however, to deliver any of these voltages to a large group of customers. For average residential service, the voltage varies all the way from 110 to 125 v. on different systems but no matter what the nominal voltage may be only a part of the customers get that voltage. Since there is always a drop in transformers and conductors, some customers get higher voltage than the average and some lower. On well consolidated systems the range may be small; on wide spread systems it must be necessarily large.

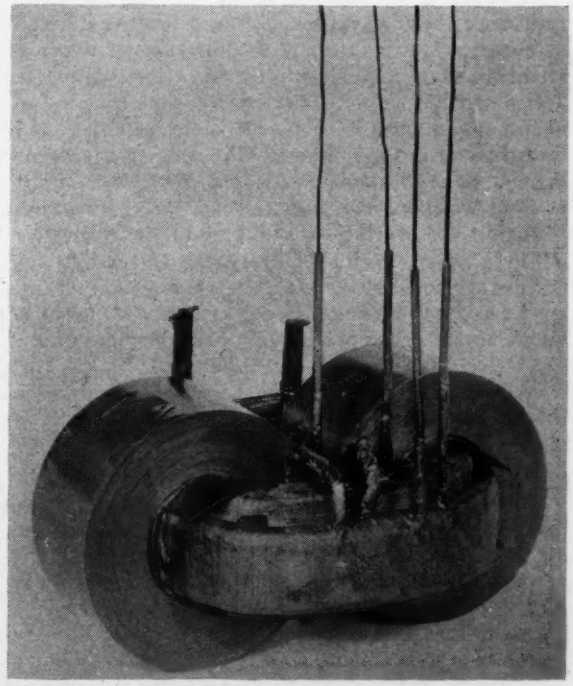
Utilization Voltage

This subject of utilization voltage formed an important topic for discussion at the fourth general meeting of the E.E.I. engineering committees held at the Edgewater Beach Hotel in Chicago in May; in fact it was the subject of a symposium under the sponsorship of J. H. Foote and H. P. Seelye. The question has many ramifications. At this meeting the general problem was presented by H. P. Seelye. Next A. C. Monteith of Westinghouse described the effects of voltage variations on most motor characteristics. Its effect on the operation of heating devices was discussed by W. F. Ogden of the Edison General Electric Appliance Co., Inc. The effect of voltage variation on incandescent lamp operation was considered by A. K. MacNaughton of the Commonwealth & Southern Corp. Another paper by Harold Cole of the Detroit Edison discussed the voltage regulation limitations imposed by the nature of the distribution system. Finally, a plan of action for utilization voltage standards was presented by J. H. Foote of Commonwealth & Southern.

As Mr. Foote pointed out, skillful compromise is an important key to the solution. He recommended that small groups of men be designated, each group to attack but one phase of the problem initially. The groups also would work simultaneously on related phases of a part of the general problem. When these groups have arrived at tentative values in term of per cent variations in voltage above and below assured bases, a joint committee of the Transmission and Distribution and Electrical Equipment Committees would undertake to fit together, these requirements to see if the requirements of some equipment is more rigid than has been determined economically possible by groups studying system capabilities. Modifications in characteristics might then be in order. In this way, eventually the spread of voltage variation needed by the supply system would be more, equal to, or less than the spread allowed by equipment design, and so gradually a reasonable solution would be arrived at.

Distribution System

Since, as pointed out above, the cost of distribution systems has been mounting, the design, operation, and coördination of distribution systems continues to be an important subject of discussion among the technical divisions of both the E.E.I. and the A.I.E.E. The Edgewater Beach meeting had several good papers on this subject. The economic design of overhead primaries was presented in a very complete and comprehensive paper by Paul H. Jeynes of the Public



The new wound core type distribution transformer described at the A.I.E.E. meeting at Washington

Service Gas and Electric Co. A new semi-underground distribution system installed at Evansville, Indiana, was described by E. V. Sayles of Commonwealth & Southern. This system comprises underground radial primary circuits with throw-over facilities to adjacent circuits and with overhead switching and transformer equipment.

These papers when considered against the background of growing system and rising costs reflect an increasing tendency towards standardization which is expected ultimately will bring about a reduction in costs. Mr. Kehoe pointed out at Atlantic City, that while a substantial degree of standardization has been accomplished without lowering costs, this he believed was due to the fact that the standardization had brought about a superior type of system and that as saturation in number of customers is reached the increment costs will be lower.

From the technical standpoint the problems of transmission and distribution of electricity are more important than those of generation and use. The problems involved in electrical machinery are mostly concerned with refinement so far as design and manufacture is concerned and with reliability as regards operation.

Fault Interruption and Lightning Protection

Fault interruption continues to be a vital problem and despite the great gains made in the last ten years in improved switching and relay equipment, further effort is constantly being expended. The session on Fault Interruption at the Washington A.I.E.E. meeting well reflects the state of the art in this branch of electrical engineering. As indicated at this session, most breakers sold today for all voltages and interrupting ratings have a rated interrupting time of .8 cycles, 0.133 sec. Some few breakers for special applications have had interrupting time ratings of 3 cycles, 0.05 cycles. Breakers of that time rating utilize the impulse oil blast principle in which oil is forced between the contacts by a mechanically driven piston. Such breakers are used on the 287 kv. circuits at Boulder Dam. During the last few years a need has arisen for breakers of a time rating between those of the standard rating of 8 cycles and the very expensive 3 cycle breakers. As a consequence of this need a new multi-break interrupter has been developed which on 138 kv. and 230 kv. systems has interrupted short circuits as high as 2,000,000 kv-a. in less than 5 cycles. Tests on these breakers were described at the A.I.E.E. meeting in Washington by Philip Sporn and H. P. St. Clair, both of American Gas and Electric.

Fault interruption naturally is closely associated with lightning protection and extension improvements have been made in recent years in lightning arrestor practice. This question has many angles and involves not only the design and development of lightning arrestors but also protective schemes using devices such as the Petersen coil and remote control systems involving high speed relays. Remote Control of Network Protection was described in a paper by Brownlee and Dent of the Tennessee Power Co., at the A.I.E.E. meeting. In this remote controlled system, the customary master relays, phasing relays and associated current transformers have been omitted from the network protectors, using in their place a remote control system of pilot wires operated from relays at the supply substation, which protects the high voltage cable feeders. The cost of this system does not exceed the cost of conventional relay installations, and it is felt that inherent hazards to reliability have been overcome.

In the design of electricity machinery an important new development is that of the wound core distribution transformers described at the A.I.E.E. meeting by E. D. Treanor. This transformer involves a radically new form of core of simple structure. It is made by winding a long ribbon of magnetic steel in a tight spiral on a mandrel into the form of a heavy walled circular cylinder. This type of construction eliminates most of the objections inherent in other types of transformers.

Lighting

In the electric lighting, aside from refinements in incandescent lamp design, the things of greatest interest at the present time are the new gaseous discharge type lamp. The sodium lamp has already become quite common for highway lighting and in large interiors the mercury vapor lamp is being used successfully in combination with incandescent lamps.

Now, the new so-called fluorescent lamps are coming into use and many of the recent papers presented before the societies have dealt with these lamps. These are tubular in form, the inside surface of the glass being coated with fluorescent material which converts the ultra violet radiation from the low pressure mercury discharge into visible radiation. These lamps produce colored light many times more efficiently than do present light sources, and in addition, fluorescence makes possible for the first time an efficient, practicable, low-wattage white light matching daylight in appearance. These lamps were demonstrated before the E.E.I. Atlantic City convention by Ward Harrison and described in a paper by Imman and Thayer at the A.I.E.E. meeting in Washington. At this meeting Gorton R. Fonda also described the fundamental principles of fluorescence in a most interesting paper.

As indicated in these various papers, the outstanding advantage of the fluorescent lamp is its ability to produce colored lights at efficiencies far exceeding those of filament lamps. Experimental 15 watt green fluorescent lamps have operated at 70 lumens per watt compared with about 0.3 lumens per watt for 60 watt filament lamps, an efficiency increase of about 200 fold. In other colors the gain is less spectacular, but still several fold. Fifteen watt fluorescent lamps of the same color as daylight have been made with efficiencies of about 30 lumens per watt, to give 450 lumens. Obtaining the same amount of light from a filament lamp, with a suitable absorbing filter to duplicate daylight requires 150 watts; i. e., ten times as much wattage and heat.

'Round About
with the Engineering Editor

F. W. Martin, who, in the old days, played Blind Man's Buff with editors at Sargent & Lundy's, is superintendent of Utilities at Hinsdale, Ill., and recently completed a new boiler plant for the city —a 400 hp. Edge Moor boiler fired by a Detroit Stoker and with a Bigelow-Liptak furnace and a 185 ft. brick chimney.

* * *

The Tomahawk Kraft Paper Co. at Tomahawk, Wis., operates almost exclusively on Wisconsin grown woods, Norway, white and Jack pine, spruce and balsam and maintains its own nursery for systematic reforestation. . O. H. Heil, engineer, says it takes from 15 to 20 yr. to grow logs to pulpwood size from seed

* * *

W. Galbraith, from over on the Peshtigo River, is in charge of the new Tomahawk Hydro Plant of the WPSCorp. on the Wisconsin River. . Built on the site of the old Tomahawk P. & P. Co. mill there are two S. Morgan Smith wheels operating under a head of 16.5 ft. and driving 1300 kw. Allis Chalmers generators.

* * *

Joe Doeffler, manager of the Kimberly-Clark Corp.'s Kimberly mill will soon have his hands full issuing, or, refusing, passes to visitors, for the TAPPI meets in Green Bay in September. . The Kimberly Mill has a 175,000 lb. per hr. B. & W. integral furnace boiler of unique design incorporating a Dutch oven for burning wet bark. . Wet bark was burned heretofore in stoker fired boilers, dropped directly on a Taylor stoker, according to C. W. Nelson, Chief Engineer of Kimberly-Clark Corp. . Geo. H. Spaulding, head of the corporation's power and steam department was in New York State giving two new 65,000 lb. per hr. integral furnace units at the Niagara Falls Mill the once over and is now busily engaged in getting out specifications for a new power plant for the Niagara, Wis., mill.

* * *

Last winter the Northern Paper Mills at Green Bay, Wis., sold its hydro plants to the Wisconsin-Michigan Power Co., a subsidiary of TMER&LCo. and to carry the electric load is now building a new power plant which Chief Engineer Harry Gochnauer says will be finished this fall. It will consist of two 75,000 lb. per hr., 650 lb., 750 deg. F. Riley pulverized coal-fired boilers with Smoot control a new G.E. steam end, exhausting at 150 lbs., on an existing 2000 kw. generator and a new 3000 kw. condensing extraction G.E. unit exhausting to a retubed and rebuilt Foster Wheeler condenser from the old 2000 kw. machine. Feed-water treatment by Permutit's new Zeo-Karb hydrogen zeolite.

* * *

From Milwaukee, Wis., J. J. Rossecky, Asst. Works Manager of Allis-Chalmers, reports a power plant modernization program scheduled for completion in October. . Four old boilers have been removed to make way for two 200 lb., 75 deg. F., 150,000 lb. per hr. Riley units. . The electrical distribution system will be expanded and a steam line run between the main and isolated power plants.

EDISON GENERATOR No. 4, which Henry Ford would like to have at Dearborn, is kept in one corner of the turbine room at the Bergstrom Paper Co. power plant, Neenah, Wis., and Chief Engineer R. A. Vanderwalker used it as an emergency exciter as late as 1916. . In the present power plant, built around 1928 as one of the pioneer 400 lb. industrial plants, men work four 6 hr. shifts, 42 hr. a week, with one shift responsible for the maintenance of each of the three boilers and the fourth for the turbine and turbine room * * * * The 6 hr. shift is used in a number of mills in the Appelton district. . Earl Hill, chief engineer of the Gilbert Paper Co., says it started during the NRA and was continued after the Blue Eagle collapsed. . Illinois has a Six-Day Week Law and schedules must be filed with the State Department of Labor and arranged to allow each man one day a week off, so that 6 hr. shifts, 7 da. a week could not be used here.

Weeds at Lakeside Station, TMR&LCo., are being crowded out of house and home, the center of the D shaped intake pond, isolated by a sheet steel crib extending almost to the rubble mound, will be filled in * * * * Mike Drewry, Assistant Chief Engineer of Power Plants, waiting for Allis-Chalmers' double barreled turbine test engineer Charlie Robertson, figured that in 1937 the average intake temperature was 4.3 deg. F. higher than at Port Washington a few miles farther north on Lake Michigan. 50.0 and 45.7 deg. F. respectively. . C. F. John, assistant to Vice President (in charge of power) G. G. Post went a step farther and found that the average monthly difference ranged from 1 to 6 deg. F. irregularly throughout the year, winter temperatures at both stations being affected by recirculation to prevent ice trouble.

W. S. Campbell, who took over Grand Tower Station of CIPSCo. when E. M. Marshall left for Powerton and who has been superintendent of Edgewater Station of EP&LCo. at Sheboygan, Wis.. for about 8 yr., has his own idea as to how a station should be operated and has worked up a world-wide visiting clientele with Australians in the majority. . He has two 675 lb., 825 deg. F. boilers with one 30,000 kw. turbine and no curtain wall, operated by a crew of 30. . Shifts are rotated and watch engineers on the relief shift head the maintenance crew. . If you know your photography don't miss his dark room and straight line production method, or, if you don't know what a needle bearing can do for rheumatism in the joints of a feedwater regulator, Campbell can show you. . The company's Riverside Station down town is now on standby service and V. E. Todd is still chief

Getting back to Illinois again. J. B. Cotter, who cut his eye teeth on a turbine blade and erected so many machines for Mr. Westinghouse that he wore out a gross of micrometers demonstrating how he lined couplings up to ¼ of a thousandth, has been superintendent of both Grand Tower and Big Muddy Stations of the CIPSCo. for several years * * * * An unusual A. M. peak on the Manitowoc, Wis., municipal plant between 11 and 12 exceeds the evening peak by about 35 per cent. due according to T. J. Gilbert, technical engineer of the station, entirely to electric ranges.

W. L. Lundy chief engineer of the Michigan City Station of the NIPSCo. while R. B. Kellogg was superintendent, and later with the Commercial Testing & Engineering Corp. in Chicago, is now test engineer for Kimberly Clark Corp. with headquarters at Neenah. Wis. . Kellogg is now superintendent of Buzzards Point Station of the PECo. in Washington, D. C.. with the yacht club next door and all of Cheseapeake Bay as a playground to indulge his yachting hobby * * * * Before the Michigan City days he was superintendent of Dresser Station of the PSCo. of Ind. on the Wabash at Terre Haute and his assistant was H. M. Sharpe, now at Buffalo, N. Y., as V. P. and Superintendent of Generation of the BNECo. * * * * Dresser Station, by the way, is a real mouth of mine plant with a belt conveyor delivering coal from the mine tipple directly to the coal hopper over the boilers. . An extension to the station has been considered for some time.

M. F. Brooks, formerly plant engineer of the Oshkosh, Wis., steam plant of the WPSCo., is now superintendent of the company's Bayside Station at Green Bay * * * * J. L. Hartney, former superintendent, is now at the South Works of the Carnegie-Illinois Steel Co. in Chicago as assistant to W. P. Palmer, Division Superintendent of Power Production and an associate of N. C. Pearcy, electrical engineer. . All three are Byllesby alumni.

Richard H. Morris

Dr. Johnstone on Sulphur Removal

From a background of 8 yr. research on sulphur removal from flue gasses, the author looks at the economic side —what has been accomplished, what remains to be done and the difference in the American and English setup

By DR. H. F. JOHNSTONE

Associate Professor of Chemical Eng.
University of Illinois
Urbana, Illinois

DR. KLEINSCHMIDT'S article in the June issue on washing flue gases deals with a matter of considerable interest to both the power and chemical industries. He has considered some of the economic aspects of the removal of sulfur dioxide and suggests that the recovery of the sulfur in some form might be accomplished at an actual net profit. While such would be the hope of anyone interested in the problem, it may be well to examine this possibility more closely in order to avoid misinterpretation by those who are not familiar with the recent technical literature.

Research on this subject in the United States has now been underway for 8 yr. In England, the investigation has extended over a longer period of time. The patent literature shows that it has been a foremost problem there and on the continent for at least 50 yr. At the present time, it can be stated that not a single process for the *removal* of sulfur dioxide from flue gases has been accepted as generally feasible. Neither has there even been one described that can *recover* sulfur in any of its forms from these gases at a profit, when the volume of production is considered along with the natural resources of this country in brimstone and pyrites. Further examination of these statements is in order.

Two processes for the removal of sulfur compounds from stack gases are now in operation in England. These are: (1) simple washing with water followed by a cleanup with alkali, as practiced at the Battersea Station in London, and (2) straight neutralization with lime slurry with the important modifications developed in the laboratories of the Imperial Chemical Industries, as used at the Fulham Station in London and at Swansea in Wales. As regards the former, there are grave doubts even in England that another similar washing plant would be permitted to dump its effluent into an industrial stream owing to the great increase in sulfate hardness of the water and to the possibility of actually acidifying entire streams during a period of drought.

For the I. C. I. lime process, not only are the capital costs of the treating plant exceedingly high on the kilowatt basis but the one item of lime alone amounts to more than a dollar a ton of coal when applied to a large percentage of the fuel used for steam generation in this country. Furthermore, in this process, as well as in all others, a third item of cost besides capital investment and operation must be considered, namely, the cost of disposal of any product. In England, the waste calcium sulfite and calcium sulfate in the form of a wet solid is hauled out to sea in one instance, and dumped on lands of low value in the other. Such opportunities obviously do not exist in general in this country. In this connection, it should be remembered that the quantity of this material from a single plant is measured in *hundreds of tons per day.*

During the course of the investigation studies of the cost of these processes as applied to conditions in the United States have been made. In addition to these, three other processes have been developed through the pilot plant stage. In each of these, recovery of the sulfur in some form has been considered. In every case a close study has been made of the design and cost of the process equipment in order to make use of the latest developments in chemical engineering upon which the entire process must be based. This study has been supplemented by consultation with competent outside engineering firms. In no case has the final estimate been low enough to show a profit for producing sulfur in competition with natural brimstone.

It should be emphasized that conditions in England are somewhat more favorable for a successful solution of the problem of eliminating sulfur compounds from the flue gases than they are in this country. Mention has already been made of the fact that the English coals contain considerably less sulfur than the large supplies of coals used here for steam generation. A second difference is the economic position of sulfur and its resources. The United States is the principal producer of sulfur in the world. In 1936, 64 per cent of the total world production came from the domes of Texas and Louisiana. All of England's requirements, however, must either be imported or recovered as a by-product. Sulfur is a basic chemical raw material. There is no substitute for it in the manufacture of explosives, rubber, paper, gasoline, and many other products. The development of any process which might be a potential source of sulfur quite probably would be regarded with favor by a nation which has depended on imports for such an important material.

It should be the aim of everyone working on the problem of sulfur dioxide removal to develop a process which will be fundamentally sound and applicable to the conditions that prevail in this country. By far the most difficult part of the problem is the economic side involved in the disposal of the large quantities of material recovered. If necessity demands, the disposal problem must be met by sending the product, whatever its nature, into the market already existing for sulfur and sulfur compounds. Then the old adage that the proper

Readers' Conference

way to remove a nuisance is to convert it into a useful product will apply. When the product is produced on such a large scale, however, there is no doubt that the whole economic situation will be changed by its development and such changes in a basic material may actually extend into related industries. Fortunately, it is not inconceivable that the chemical market may be able to absorb all of the sulfur produced as a by-product but, in order to do so, new products and new methods based on the predicated economic balance must be considered. A complete research investigation on sulfur removal should include these possibilities.

In summary, it is evident that cleaning waste gases is now and will be an expensive proposition, regardless of what method is used. Any income from the sale of a product will be welcomed but actual profit is remote at present.

Finally, the writer suggests that Dr. Kleinschmidt did not wish to infer in his article that the wet cyclone type of scrubber was the only one that can be used for the simultaneous removal of dust and sulfur dioxide from flue gases. The installations at Fulham and Swansea utilize other methods to accomplish the same thing. The design of scrubbers for treating large quantities of dust-laden gases has been a part of the investigation with which the writer has been connected. The results have been published in several papers appearing in the technical journals.

Clamp Static Wires Carefully

STATIC WIRES, grounded at a number of points, are installed on many poles or tower transmission lines to afford a means of dissipating atmospheric electrical disturbances which might cause surges or other line troubles. This wire is ordinarily strung on metal arms at a safe distance above the topmost current carrying conductor, and is fastened to the supporting metal with clamps. These clamps are bolted tightly at ground connections to afford a low resistance path for stray currents.

When stringing static wires, the greatest care must be used to avoid any possibility of the wire breaking when in service and grounding or short circuiting the feeders beneath. Tension must be carefully calculated, making allowances for any change in temperature that might impose undue strain. Clamps must be lined up carefully, or they are likely to nick the wire when tightened.

The importance of proper clamp alinement can be illustrated by the difficulties recently experienced on a 6600 v. pole line feeding signals and other essential services on a division of a large Southern railroad. This line, erected during the summer months, was constructed with copper feeders. The static wire, however, was copper-clad steel. During construction this wire was damaged when tightening its clamps, seriously reducing the cross-section and exposing the steel core to corrosion. When cold weather set in and the tension increased due to contraction, the weakened static wire broke at these points and caused a number of troublesome interruptions.

Since these breakages continued for a number of years due mainly to the gradual weakening effect of a progressive corrosion, accentuated, no doubt, by sulphur compounds from locomotive stack discharges, it was eventually necessary to restring the line, using copper wires and taking pains to see that all clamping devices were in perfect alignment, before they were bolted up.

Roanoke, Va. S. H. COLEMAN.

Motor Maintenance

THERE is an economic crux to every motor overhaul problem. Many are asking, are we spending too much or not enough money on motor maintenance? There are various answers after a thorough analysis of each installation but always it reverts back to the question of "how much"?

"Yearly" overhauling is entirely too general a rule to follow on all motors. Temperature and atmospheric conditions usually vary with motor locations and this reflects itself in the final condition of the insulation and bearings. Also the type of motor, "open", "splash-proof" or "totally enclosed" for the various locations is a decided factor. An "open" motor will require continual inspection and frequent overhauling if installed in an abrasive dust or chemical fume atmosphere.

The loads the motors operate at also reflect the insulation condition. A motor operating at 105 per cent load 8 hours and full load the remainder of the 16 hours, day in and day out, will bake out and shorten the life of the insulation and will require more frequent overhauling than a motor which operates at 75 per cent load for 24 hours.

The following should be determined: (1) how much in dollars and cents per horsepower it costs to overhaul the various types of motors in the various locations and (2) how much it will cost in the process or operation (including labor costs if any) if an interruption occurs, for the time it would take to effect repairs to windings or to replace with a spare unit (if available). This will ease one's mind somewhat as to how much one should spend per year on overhaul or inspection insurance and from the former figure one can determine how many overhauls one interruption will pay for. Some find it cheaper to burn out a motor or two every year instead of spending twice the repair or replacement cost in overhauling all motors.

With regard to periodic inspection they should be made by competent, reliable individuals. A good way is to have the individuals fill out a form sheet and have them sign their names to the inspection details. This shoulders them with responsibility. It would be preferable to have employees who have been with the company a considerable length of time on this job because they will be loyal and can be trusted to give authentic details. It would be preferable to have bimonthly "thorough" inspections, rather than weekly "superficial" inspections made by incompetent individuals.

If overhauling has been deferred for a considerable length of time it would be well to overhaul one or a few motors and make a thorough inspection of the insulation and all the mechanical parts. The motors chosen should be in typical locations, operating under typical service and loading conditions. From these overhauls and inspections one will be able to decide whether the overhauling period can be further extended without danger to the equipment or whether the motors should be overhauled more frequently.

Tenafly, N. J. KERMIT B. HOFFMAN.

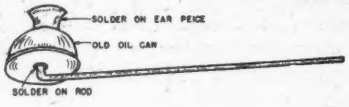
Corroded Condenser Coils

IF SMALL pits exist in condenser coils not more than 1/16 in. deep they can be filled up by acetylene welding. The pits should be cleaned down to the bare metal with a stiff wire brush and then filled. If the corrosion exists over a large area or the pits are deep, that part of the coil should be cut out by an acetylene welder and a new section of pipe welded in. These coils should be kept painted with pure red lead paint, this being a good preventive of corrosion. Before painting, the piping should be well cleaned. Any minute pits which are found should be well cleaned and then filled with red lead, this will prevent the corrosion spreading further.

Sussex, England. W. E. WARNER.

Homemade Helps

A VERY handy and simple little contrivance for detection of knocks can be made from a discarded old oil can and a bit of small iron rod bent and soldered to the bottom of the can, together with an ear piece



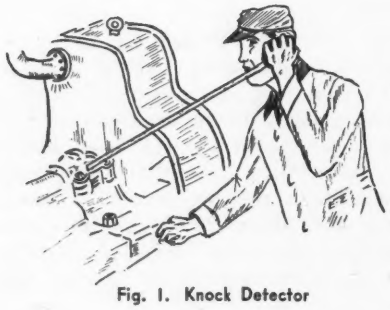


Fig. 1. Knock Detector

over the oil can opening at the top as shown in the sketches. In using the device, the end of the rod is placed at various parts of the machine or unit that is making a noise and by listening to the intensity of the noise at various spots it can be traced down to its source.

For that extra little bit of leverage sometimes needed to start open or to close firmly a valve, or for use where any handwheel is a part of the operating job, a handy, quickly applied and portable extension grip can be made as shown in Fig. 2. Use is made of a section of flat plate for the base on which two

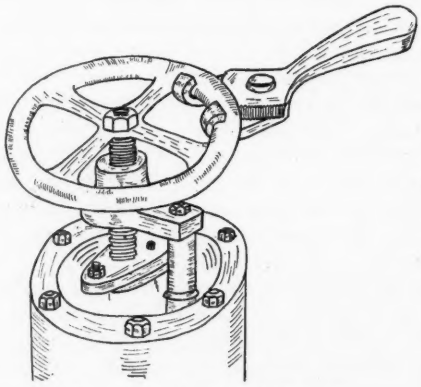


Fig. 2. Hand wheel extension grip

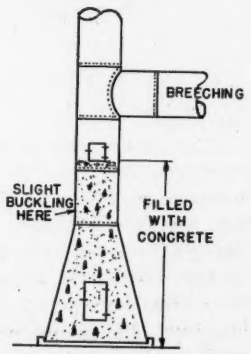
lugs or tabs are formed hook shape. A hole is drilled, for mounting the quadrant-shaped, eccentric-pivoted, toothed-face, gripping handle. The story of its use and design can be understood fully from the sketch. A couple of sizes of these on hand will be able to handle a lot of different diameter wheels.

Penacook, N. H. CHARLES H. WILLEY.

First Aid for Stacks

SOME TIME ago a metal stack, 42 in. in diam. with a 6 ft. base and two courses below the breeching connection, showed signs of weakness in the bottom section directly above the first course. Corrosion resulting from infrequent cleaning caused this portion of the stack to be considerably thinned, holes were noticeable here and there and a slight buckle had developed just above the riveted joint. Inspection showed that the stack from the second course up was still in good condition.

$110 worth of concrete saved stack from the junk pile



After some consideration temporary repairs seemed practical. A small opening to be used as a cleanout door was, therefore, cut in the course directly below the breeching connection and the base was filled with concrete. The concrete, using scrap metal pipes, rods and old tubing as a reinforcement, was poured up to the level of the new cleanout door or about 8 in. above the second row of rivets. This strengthened the base of the stack and will provide a foundation for a new and larger one if necessary in the future. The cost of this repair job was about $110.

Ansonia, Conn. WILLIAM THOS. ESTLICK.

Noise in Boilers

WHEN STEAM is taken intermittently from a boiler as for instance when operating a reciprocating engine or a large waterworks pump and the steam flows out in regular beats or pulsations, it is liable to impart a tremble to the boiler. One day I cut in a boiler and did not open the globe stop valve wide. In a little while the inside disc of valve, which was loose on its stem, began to rattle in unison with the pull of the engine running off the steam line. On opening the valve wide the noise stopped.

Many readers have seen cases where, when observing the steam gage just after punching up the fire, as the steam flow begins to increase, the gage hand will often wiggle and "sorta do the Charleston".

Then again, there may be noises originating from running machinery that are transmitted back to the boiler through the steam line. Here is a case of long distance transmission of noise. I was called by a man who lived about a mile from the central station asking me to call at his residence to see about an unusual noise from his water pipes. I found that although he was more than a mile from the plant the noise of operation of a big compound duplex water pump could be heard plainly in his bath room. He said that he had not heard it before. I suddenly remembered that the day before I had been caught with a fire with the steam rather low and as this pump was built so that I could switch high-pressure steam into the low-pressure cylinders to get more power, I had done so until I got my steam pressure up, and I had forgotten to close the control valves afterward, so that we were still using high-pressure steam in the low-pressure cylinders. I went back to the plant, changed over the pump and the noise ceased in the water mains. The pump was not perfectly cushioned for the emergency running and this put noise on the mains, but it seemed strange that the trouble was more noticeable at a distance than near by.

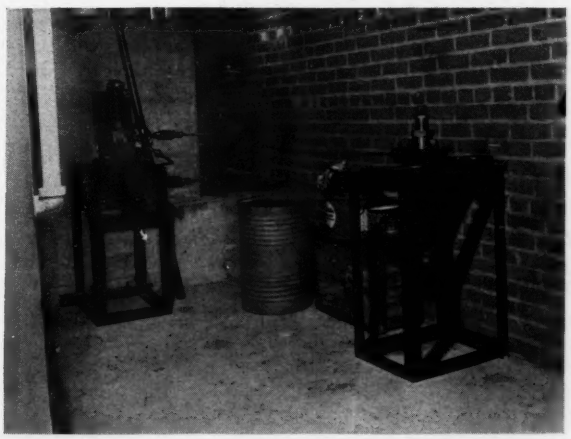
Then there was the case of the boiler which screeched. This was an old flat bottomed locomotive firebox type that was first used on a ferry boat but later salvaged and put into a wood-working planing mill job for motive power. It was set flat on some I-beams laid in cement and the front end of the boiler was fastened to the I-beams but nowhere else. When the boiler was being fired from cold, after getting about so hot it would let out a terrific screech, enough to scare the fireman clear off the job, if the matter was not explained to him beforehand. The screech was merely the rear end of the boiler moving on the I-beams to take care of expansion. It probably moved only a fraction of an inch but it was enough to make plenty of noise.

Water hammer in pipe lines can cause pulsations affecting the boiler. Other defects like steam lines, put up too rigid, can transmit stresses to the boiler. When one of those old time throttling governor engines was operating a saw-mill, if the saw would strike a hard knot, it would set the throttling governor to bobbing and this irregularity in the pull of steam would be transmitted back to the boiler. Now and then it would set the old arm-and-lever safety valve weight to bobbing and the head-sawyer would get a section of grate-bar to hang on the lever to stop it. I don't know whether this could be called a case of the dog wagging the tail or the tail wagging the dog.

Logansport, Ind. C. C. CUSTER.

Diesel Spray Valve Testing

PROPER maintenance, testing and adjustment of spray valves, or, fuel oil injection nozzles for Diesel engines is an important factor from the standpoint of economy and service. In an article on page 449 of the July issue of POWER PLANT ENGINEERING, John M. Drabelle, Mechanical and Electrical Engineer of the Iowa Electric Railway & Power Co., went so far as to say that a testing pump and gage for this service is the most necessary piece of equipment in a power station. The accompanying photograph taken in the basement of the new Diesel station of the Wisconsin Power Cooperative, described on page 426 of the same issue, shows the test pump and test rack. The spray nozzle on the right hand rack is in position for testing. In order to obtain the high pressure necessary for this purpose, the pump is made with a small plunger and a long handle. This handle, shown on the left, leaning against the test rack, is detachable.



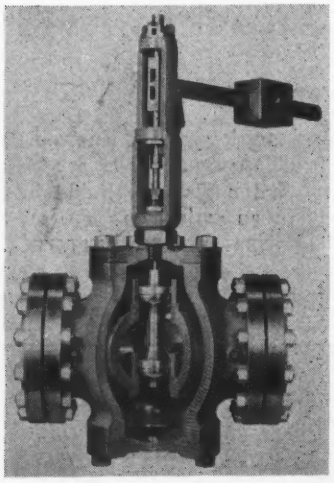
Spray valve test rack at Chippewa Falls Station

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

Balanced Lever Valves

FOR USE with steam, air, oil, water and most any gases, these Series 42 balanced lever valves, have been announced by A. W. Cash Co., Decatur, Ill. In Type 42-R Valve the roller guided top works to insure free valve movement, perfect valve stem alinement, tight seating, longer packing life, and minimum of friction. Valve stem is roller guided top and bottom. These valves have the following features:



nitralloy rollers and roller pins, no lost motion, double or single seat, hefty renewable seat rings, weighty walls, uniformity throughout and precision machined. Any type inner valve can be furnished, including parabolic type; flat type with bevel seat; V-port type with bevel seat; and V-port type, non seating. They are available in any size, and materials, ½ in. to 3 in. screwed ends; 1 in. to 12 in. flanged ends.

Ignition Lag Indicator for Diesel Engine Fuels

THE IGNITION quality of Diesel engine fuels can be determined accurately and speedily with the Aminco Penn State Ignition Lag Indicator recently introduced by the American Instrument Co., Silver Spring, Md.

The inherent accuracy of the instrument in rating Diesel fuels is greater than one-fourth cetane number, and with it, the ignition quality of from 10 to 15 fuels per hour have been determined in actual practice; thus it is more reliable than the bouncing-pin method and about ten times faster.

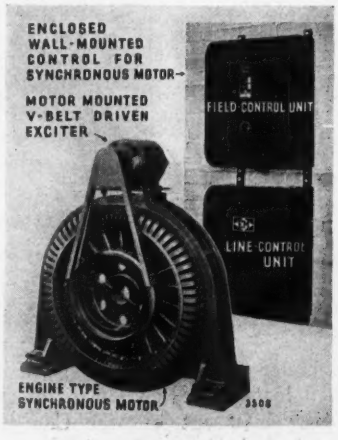
This indicator, which is supplied to fit the standard Waukesha C. F. R. Diesel test engine, can be installed in about one hour by the average operator, and with it, any person qualified to operate the test engine can readily grasp the method of conducting satisfactory tests.

The method consists of injecting the fuel at a given time before top center, and adjusting the compression ratio to give ignition at top center, as measured by the indicator. The fuel whose ignition quality is unknown is bracketed between two known fuels.

The apparatus consists of magnetic pick-ups for detecting the injection and ignition impulses, a double thyratron relay for converting these impulses into short-lived surges of electricity, and a neon protractor mounted on the flywheel and bearing two neon lamps (set at a known angular distance from each other) to convert the impulses into a visual signal.

Synchronous Motor Equipment for Small Compressors

TO MAKE direct-connected synchronous motors more practical and advantageous for smaller industrial reciprocating compressors requiring down to 40 hp., Electric Machinery Mfg. Co., Minneapolis, Minn., has recently developed a new type of equipment. This equipment makes possible lower first cost, simpler installation, and smaller floor space requirement than has previously been attainable with synchronous motor drive for air and gas compressors, and for refrigeration compressors used for air conditioning and other cooling purposes.



Features of new equipment are (1) exciter mounted on top of the synchronous motor, V-belt driven from a sheave on the rotor of the motor, and (2) the automatic, enclosed wall-mounted control which is supplied instead of the usual panel-mounted starter.

The motor-mounted exciter eliminates the floor space and extra wiring necessary where a separate induction motor generator set is used for excitation. The wall-mounted, enclosed control requires relatively small space, is simple to install, and has lower first cost than panel-mounted control equipment. The Line Control Unit is magnetic, full-voltage type with overload and under-voltage protection. The Field Control Unit is slip-frequency responsive type for automatically applying and removing motor field excitation.

U-Bolt Valve

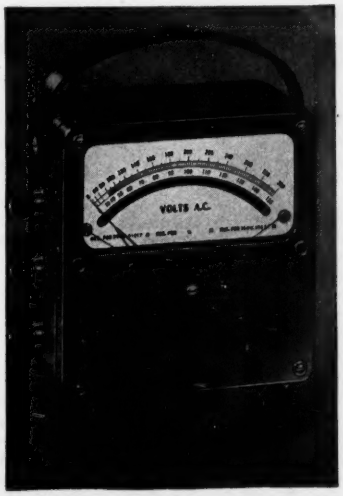
JENKINS BROS., 80 White St., New York, N. Y., has just announced a new line of bronze mounted and all-iron U-bolt gate valves. This is the result of a definite effort to improve the design and construction of this type of

valve, which has wide popularity where a husky, general utility valve is desired as it combines exceptionally quick, easy disassembly for inspection or repair, with high resistance to springing and distortion. A renewable bonnet-saver-bushing makes it unnecessary to junk the valve bonnet when operating threads are worn. By slipping a new bonnet-saver-bushing into position, the user obtains good as new thread engagement in the same old bonnet. This bushing can be lifted out so the user can get into the upper part of the bonnet chamber to do a thorough job of cleaning out deposits that may form there.

Improved Temperature Compensation on Multi-Range A.C. Voltmeters

PORTABLE multi-range Model 433 a.c. voltmeters with improved temperature compensation are now being offered by the Weston Electrical Instrument Corporation, Newark, N. J. The improvement will be of particular benefit in field test work by public utilities, wnere temperatures ranging from –20 deg. to 120 deg. F. may be encountered

Instruments of the double-range type (300/150 v.) and the triple-range type (600/300/150 v.) are available with the improved compensation which holds tem-



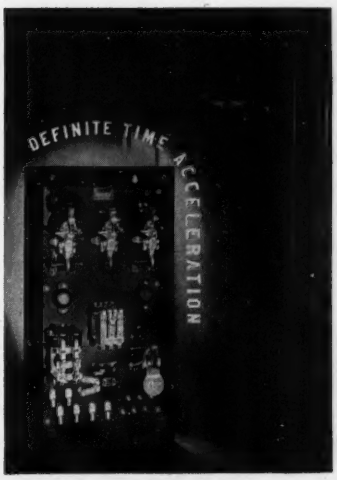
perature errors to 1 per cent for 60 deg. C. (140 deg. F.) on both the 150-v. and 300-v. ranges and to 1 per cent for 240 deg. C. (464 deg. F.) on the 600-v. range.

Due to the special internal connections on these improved instruments, switches are used for range changing purposes, the switch for the double-range instrument being a double-pole, double-throw toggle switch, and that for the triple-range type a double-pole, 3-position rotary switch. Otherwise the instruments are similar in general specifications to other "Model 433" portable a.c. meters.

New D. C. Heavy Duty Controllers

A NEW LINE of d.c. heavy duty controllers including non-reverse and reversing types, with and without dynamic braking for both constant speed and adjustable speed motors for all machine tool applications, for heavy duty applications below 10 hp. and for general purpose above 10 hp., is announced by Cutler-Hammer, Inc., 295 North 12th St., Milwaukee, Wis.

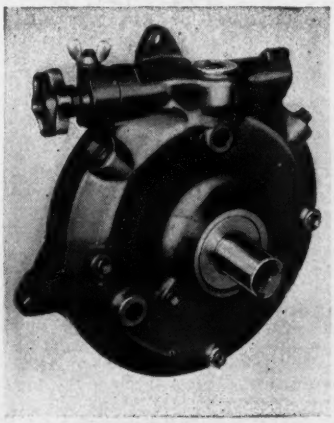
A new timing device which operates magnetically on the principle of a condenser discharging through a magnet coil provides simple, positive, precise, definite time acceleration which is unaffected by load, temperature or other working conditions. Once adjusted to obtain the desired starting period, the controllers will always accelerate in this same time. The operator quickly becomes accustomed to this uniform performance and will automatically increase his productive efficiency.



Other construction features include: a new styled case which harmonizes with any surroundings; snap-on type cover which can be completely removed for installation and wiring; a tilting panel frame which allows quick, easy access to the rear of the panel at all times; a wiring trough in the rear compartment which facilitates wiring and which effectively shields rubber covered wire if used; heavy duty contactors used throughout; and heavy duty non-breakable or grid type resistors. They are available for use with either push-button or drum type master switch and in all standard NEMA ratings up to 75 hp., 115 v. and 150 hp., 230 and 550 v.
News Note

Variable Speed Control

DEVELOPED by Morse Chain Co., Ithaca, N. Y., primarily for the milling industry to provide an accurate, dependable, variable speed feeder drive, the Morse variable speed control is a simple, positive mechanism for governing the speed of output shafts through an infinite number of variations within the range of the unit. With the input shaft operating at the recommended speed of 180 r.p.m., the Morse variable speed control can be quickly adjusted by a hand set with visible dial to deliver from 1½ to 40 r.p.m. through the low speed shaft, or any possible speed in between these two limits. Since the introduction

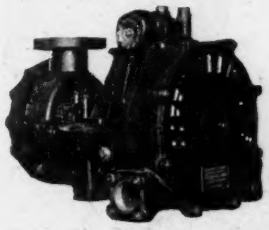


of the Morse variable speed control, many applications in other industries have presented themselves. The construction of the unit is simple, sturdy, and will give long service. It is self-contained, and therefore cannot be affected by dust or dirt conditions. There is not a single bolt, nut, or part inside the case which can become loosened and cause trouble. The Morse variable speed control unit is easily installed—simply couples to the shaft and bolts on the machine frame by three bolts. Right or left hand units are available.

Turbine Driven Boiler Feed Pump

THE J. S. COFFIN, JR., CO., Englewood, N. J., announces the entry into the industrial power plant field of a new line of integrally built turbine driven boiler feed pumps.

A single bearing casing and shaft serves both the turbine and pump. A carefully worked out end assembly makes renewal of parts especially easy. The unit is very small in size, the largest size delivering 175,000 lb. per hr.



against 500 lb. pressure, measuring only 28 in. by 21 in. by 20¼ in. The smallest size has a nominal delivery of 70 g.p.m. or 35,000 lb. per hr. A twin unit will feed up to 10,000 b.hp. High speed, single stage construction is used throughout, making for high efficiency and the most economical use of materials. Stainless and alloy steels are used liberally. Extra long balanced wearing ring surfaces are provided with self-adjusting packing which packs only against suction pressure. An overspeed trip is used, equipped with a hand trip and resetting lever.

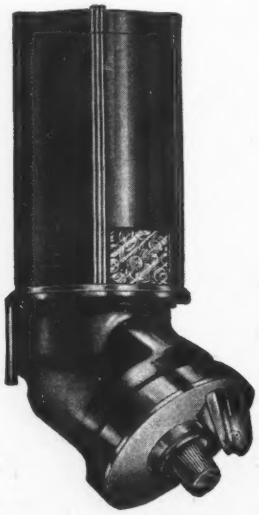
Megohmer

HERMAN H. STICHT & CO., 27 Park Place, New York, N. Y., has made an improvement in its Model DM Megohmmeters for insulation resistance measurements. The standard megohmmeter, whether it be known as a Megohmer or some other name, has a scale which is directly reading in megohms and fractions of a megohm. The man who has not had experience in the measurement of insulation resistance sometimes encounters difficulty in judging the condition of the insulation by these readings. Reliable information for the interpretation of the readings has been rather scarce. This is largely the result of the complete absence of any legal requirements as to insulation resistance values.

In this modification of the instrument an attempt has been made to signify by the color of the scale graduation whether the insulation under test is good, fair or doubtful, just as the color scale has been used in the radio tube tester.

New Dispenser

THIS new dispenser, made by the Industrial Products Co., 703 Somerset St., Philadelphia, Pa., is used for the purpose of dispensing sodium chloride tablets. These tablets are compressed of pure sodium chloride and taken to prevent heat sickness. Capable of holding 1500 tablets, this dispenser is all plastic



moulded and moisture proof. It has a visible tablet reserve and discharge. Placed beside the drinking fountain these tablets and dispenser provide a convenient and sanitary means of supplying workers one tablet at a time with a swallow of water. A total of four to six tablets during a work period is usually sufficient to maintain the proper salt balance in the body.

Sight Flow Indicator

THE NEW flow indicator developed by Fischer & Porter Co., Philadelphia, Pa., for rugged service use where corrosion problems will be encountered consists of a pipe fitting (screwed or flanged) with two heavy bull's eye glass sight disks located opposite each other in the fitting. The bull's eyes are held in place by heavy bolted cover plates which can be easily removed to renew the packing under the bull's eyes or to clean the glass. The packing is usually either neoprene or thiokol. Other materials used on request.

The flow indicating device is a flapper which hangs vertically downward against an opening through which the flow must pass. Fluid passage pushes

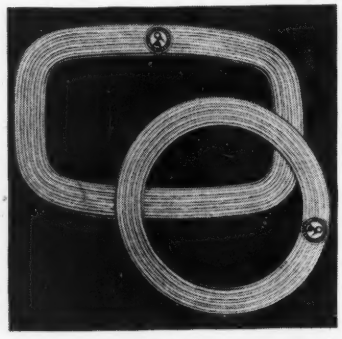
the flapper outward and upward thus giving indication of flow. The indicator does not show how much flow is passing but merely that there is flow. However, some measure of the magnitude of the flow can be obtained by noting the angle from vertical to which the flapper is swung.

Both body and flapper can be made of practically any machinable or grindable metal and the pin which holds the flapper is made especially heavy to give long life.

Sizes range from ½ to 3 in. The indicator can be installed in any position except for flow vertically downward but downward flow elbows can be placed in the line to give a short piece of horizontal pipe where the indicator is located.

Metallized Gaskets

CORRUGATED metal-asbestos gaskets of a new type treated with a special metallic compound which, it is claimed, adds greatly to the gasket's resistance to heat, pressure, moisture and corrosion, have been announced by Goetze Gasket &



Packing Co., Inc., of New Brunswick, N. J. This metallic coating also has the advantage of preventing the asbestos from sticking to flanges and minimizes damage to gaskets from handling.

Continuous Blowdown

CONTINUOUS blowdown, while furnishing an efficient method of controlling boiler water concentration, priming and foaming, usually has presented difficulties in accurate metering and valve maintenance. Both problems are attacked by a new kind of continuous blowdown assembly recently developed by The Strong, Carlisle & Hammond Co., Cleve-

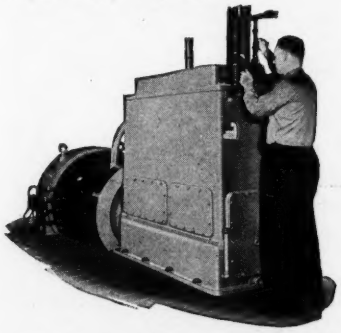
land, O. The system is based on an initial pressure drop ahead of a special, steel blowdown valve.

Pressure is reduced by a fixed Anummetl orifice that determines the maximum flow. This results in a proportionate increase in volume, due to reflash. Accuracy of control through the blowdown valve, therefore, is multiplied in the same ratio that the volume has been increased. Regulation is made still more exact by the special restricted seat and the position indicator of the blowdown valve. At the same time, the reduced pressure subjects the valve to less severe service, greatly prolongs its life and reduces maintenance.

Standard valves are furnished for pressures to 650 lb. or temperatures to 800 deg.

Four-Cycle Gas Engine

BRUCE-MACBETH ENGINE CO. of Cleveland, Ohio, has just announced a four-cycle gas engine of comparatively light modern streamline design, known as the Type G and developed to meet the growing demand for lighter, more compact heavy duty engines.



All moving parts with the exception of the flywheel are enclosed within the engine housing, yet are easily accessible for inspection and adjustment. Outstanding among the many special features of these engines is the utilization of the Bruce-Macbeth method of cooling without a water jacket. A simple and dependable air starting system is provided. All parts which require cooling are submerged, yet visible and accessible. Overflow pipes maintain a constant, required water level and provide for complete circulation and a uniform engine temperature.

These engines are conservatively rated, provide liberal horsepower reserve and operate on gas of any heat value from 125 to 3000 B.t.u. per cu. ft. They are available in 6 cyl. at 170 hp.; 4 cyl. at 115 hp.; and 3 cyl. at 85 hp.

Oil-Proof Transmission Belt

RECENTLY perfected by The Manhattan Rubber Mfg. Division of Raybestos-Manhattan, Inc., Passaic, N. J., Paranite-G. O. P. transmission belting solves a serious machine shop problem. One of the greatest disadvantages in the use of rubber belting has been the destructive action of mineral oil on rubber friction compounds. Because of this rubber belting has been looked upon with suspicion by machine shop operators.

To meet this condition, after a long period of research and the experimental use of many belts in the field, Manhattan has developed the Paranite-G. O. P. (Gas and Oil Proof) belt. There is no natural rubber in these belts, the friction compounds being of recently perfected G. O. P. synthetic material, which may be used and compounded as is rubber. Oil accumulating on the belt, as is common in, machine shops, in automobile manufacturing plants, and in other factories, will not cause swelling or deterioration.

News from the Field

JONES & LAUGHLIN STEEL CORP., Pittsburgh, has completed a modern wire rope plant at Muncy, Lycoming County, Pa., to be known as the Gilmore Wire Rope Division of the Jones & Laughlin Steel Corp. It began operation about July 1st, 1938, and marks the entry of the Corporation into a new line of finished products including wire rope for oil country use, for general construction purposes and for industrial application.

OFFICIALS of the General Electric Co. celebrated both the company's 60th year of existence and the beginning of construction on its building for the New York World's Fair 1939 on June 22 by driving a copper cachet 90 ft. into the earth at Flushing, Long Island. The foot-long copper tube, containing a dedication, photographs of the fair grounds and model of the G-E building, and a list of those officiating and attending, served as a modern version of the conventional cornerstone-laying. It was sealed and attached to the bottom of the first pile to be driven on the building site. Charles E. Wilson, executive vice president of the company, with the expert assistance of a regular crew, operated the pile driver which drove the dedicatory receptacle deep into the ground. Grover Whalen, president of the Fair, and Charles W. Appleton, G-E vice president and chairman of the company's fair committee, assisted in the ceremonies. Luncheon was served afterwards in the administration building, with Owen D. Young, G-E board chairman, acting as host.

FLYNN AND EMRICH COMPANY has appointed William J. Christie as Chicago District Sales Engineer. Mr. Christie was, for many years associated, as sales manager, with one of the larger Chicago stoker manufacturers. R. J. Murphy has recently become associated with this company as Cleveland District Sales Engineer. Mr. Murphy has lived in Cleveland many years and has some very desirable other accounts.

STANDARD METHODS Adopted for Centrifugal Fans and Blowers is available in the second edition as Form X-12 from the National Association of Fan Manufacturers, General Motors Bldg., Detroit. This differs from the first edition only in the fact that the material has been rearranged and the comparison charts enlarged.

UNITED CONVEYOR CORP. of Canada, Ltd., has announced the appointment of Taylor Engineering & Construction Co. Ltd. of Toronto as exclusive agents for the Ontario territory.

PAPERS SUBMITTED in the $200,000 Award Program of The James F. Lincoln Arc Welding Foundation are being judged at Cornell University, Ithaca, N. Y., by the Foundation Jury of Award which convened July 2. Thirty jurors from engineering departments of various colleges and universities will judge the entries under the direction of Dr. E. E. Dreese, of Ohio State University, Chairman of the Jury of Award. To assist in properly appraising the merits of any paper, the Jury of Award will consult experts or outstanding authorities in the various classifications of the Award Program.

THE BOSTON OFFICE of Allis-Chalmers Mfg. Co., has been moved to the Park Square Bldg., located at 31 St. James Avenue. W. F. Taylor remains in charge as manager.

WILLIAM J. DALY, formerly Detroit District Sales Manager for Worthington Pump and Machinery Corp., has been transferred to the corporation's Philadelphia office to succeed C. H. Shaw, deceased. Graduated from Notre Dame University in 1922, Mr. Daly joined the Worthington organization in the same year as a student engineer. Since that time he has held various important positions in the corporation, some of which were: special engineer in air compressor sales; assistant sales manager of its Cincinnati Works; manager of its Industrial Sales Division; and Detroit district sales manager. Mr. Daly will be assisted by W. J. Van Vleck, recently appointed assistant manager, in the Philadelphia district.

REPUBLIC FLOW METERS CO. announces the appointment of the Frye Engineering Co., 209 Farnsworth Bldg., Memphis, Tenn., as representative in that portion of Kentucky, Tennessee, Mississippi and Arkansas in the Memphis area. This company will handle the complete line of Republic instruments and Smoot control equipment.

RAYMOND SZYMANOWITZ, formerly technical director of Acheson Colloids Corp., has been moved up to vice president and technical director of Acheson Industries, Inc. In his new capacity, Szymanowitz will continue supervision of all research activity of Acheson Colloids Corp., Port Huron, Mich.

BALDWIN-SOUTHWARK CORP., a subsidiary of the Baldwin Locomotive Works, has been awarded the third hydro-electric turbine for the T.V.A. water power development at Chickamauga Dam at approximately $500,000.

Dr. Walter A. Jessup

DIRECTORS of Johns-Manville Corp. at their June meeting established a policy of widening the board's membership to include not merely stockholders' interests but direct representation for the viewpoint of the general public, Lewis H. Brown, president, announced. To serve this purpose of interpreter of the public viewpoint in correlating modern corporation policies with these newer concepts, the Johns-Manville directors elected to the Board of Directors Dr. Walter A. Jessup, President of the Carnegie Foundation for the Advancement of Teaching. Dr. Jessup has had a long and distinguished career as an educator, primarily in the Middle West. He was successfully Superintendent of Schools in various Indiana towns, Dean of the School of Education at the University of Indiana and at the State University of Iowa, and from 1916 to 1934 President of State University of Iowa. For the last four years he has been president of the Carnegie Foundation.

PWA Power Plants

SOME 24 power projects involving a total estimated cost of $13,158,848 was approved recently and announced on Federal Emergency Administration of Public Works release No. 3368. None of these compete with private systems. Most of these cover additions to existing stations and in some cases, include waterworks and sewage plants. In a few cases only street lighting, distribution systems or transmission lines are involved. The list is as follows:

Location	Type	Docket No.	Est. Cost
Arcadia, Wis.	Steam	1190	$ 28,000
Austin, Texas	Distr.	1847	350,000
Blackwell, Okla.	Steam	1132	207,500
Bluffton, Ind.	Boiler	1390	20,000
Camden, N. J.	Steam	8207	390,909
Chapel Hill, N. C.	Steam	1074	306,500
Cleveland, Ohio	Steam	1610	1,680,000
Columbia, Mo.	Distr.	1313	1,085,000
Farmville, N. C.	Diesel	1142	177,275
Fort Morgan, Colo.	Steam	1217	300,000
Garrett, Ind.	Boiler	1377	39,000
Goshen, Ind.	Diesel	1385	89,050
Jacksonville, Fla.	Steam	1035-3	2,503,000
Ketchikan, Alaska	Distr.	1026-3	4,200
Lockport, Ill.	Light	1842	7,272
Lund, Nevada	Diesel	1034	34,545
Manti, Utah	Hydro	1144-1	75,297
Montgomery, Ala.	Distr.	1183	220,000
Platte Co., Nebr.	Trans.	665-3	5,190,000
Rayville, La.	Diesel	1018-2	70,000
Traverse City, Mich.	Steam	1213	125,000
West Milwaukee, Wis.	Light	1408	58,000
Wauwatosa, Wis.	Light	1421	136,000
Weatherly, Pa.	Steam	1666	59,300

A subsequent release No. 3370 listed 21 plants, involving $15,171,845, which received conditional approval. These plants, if erected, would compete with privately owned facilities, and the PWA funds will be available only after the municipalities have made reasonable efforts, in good faith, to acquire the private utility. With two exceptions these cover new plants, the two exceptions are in the TVA territory and involve only distribution systems.

Location	Type	Docket No.	Est. Cost
Caruthersville, Mo.	Diesel	1270	$ 175,000
Cleveland, Okla.	Diesel	1225	142,000
Columbus, Miss.	Distr.	1213	281,000
Covington, Va.	Steam	7105	403,636
Cuero, Tex.	Diesel	1477	225,000
El Dorado, Ark.	Diesel	1165	663,000
Fairport Harbor, O.	Diesel	1465	155,000
Galax, Va.	Diesel	1016	287,000
Gonzales, Tex.	Diesel	1482	173,000
Meridian, Miss.	Steam	1073	1,418,182
Mt. Pleasant, Mich.	Diesel	1350	485,000
Murfreesboro, Tenn.	Distr.	1221	245,455
Newton Falls, Ohio	Diesel	1531	205,000
Okmulgee, Okla.	Diesel	1227	904,000
San Antonio, Tex.	Steam	1826	6,137,300
Saranac Lake, N. Y.	Diesel	1481	500,000
Texarkana, Tex.	Diesel	1276	545,000
Weslaco, Tex.	Diesel	1939	210,000
Wharton, Tex.	Diesel	1548	200,000
Westbrook, Minn.	Diesel	1152	67,272
Wichita Falls, Tex.	Diesel	9630	1,750,000

A. I. E. E. at Portland

THE PACIFIC COAST CONVENTION of the American Institute of Electrical Engineers will be held at Portland, Oregon, Aug. 9 to 12, with headquarters at the Multnomah Hotel. An interesting program has been arranged involving a general session and five technical sessions on specialized subjects. Two student technical sessions will be held and there will be a student-counselor dinner and conference on the evening of the opening day to which all interested in student activities are invited. There will be a choice of inspection trips to Bonneville Dam, Ariel Hydro plant, Oak Grove plant, Pacific Telephone Co. plant, and other points of engineering interest. John C. Parker, President-elect of the Institute, will present an address on "Engineering Orientation" at the opening general session.

Samuel Insull

SAMUEL INSULL, who came to this country at the age of 21 and carved himself an empire, died on July 16 of a heart attack as he was presenting his ticket in a Paris subway station. Alone at the time, with but 30 francs in his pocket and identified by a hotel laundry slip, his passing was in pathetic contrast to the days when he was Chicago's leading citizen, a figure of world wide importance and dictator of a utility empire stretching from the Atlantic Ocean to the Rocky Mountains and from Mexico north into Canada.

His empire collapsed in 1932, sweeping away his personal fortune and bringing ruin to thousands of investors. When embezzlement proceedings were started against him, he fled, but after a chase through Europe which occupied the headlines for months, was arrested, tried and later acquitted of charges of embezzlement and using the mails to defraud. Of recent years he lived quietly in Chicago on a pension from the Commonwealth Edison and Peoples Gas and Public Service Co. of Northern Illinois, and was frequently in the Monadnock Building to call upon an old acquaintance and associate. Always friendly, his haggard and harrassed appearance during the trial in 1934 was in striking contrast to the hearty optimism displayed of recent months.

He sailed from Montreal June 30 on the Ascania which ran aground in the St. Lawrence River, and he was transferred to the Montcalm. His son, Samuel Insull, Jr., now assistant to James Simpson, chairman of the Board of the Commonwealth Edison Co., feels that the strain and excitement may have been a contributing factor to the fatal heart attack. He had arrived in Paris the Monday preceding his death and was staying at a hotel with his wife, the former Margaret Bird. Burial was in Putney Vale Cemetery on the outskirts of London beside his parents.

Arrogant, dictatorial and headstrong, ruling his empire with a hand of iron, brooking no interference and inspiring fear, he accomplished much and none of the misfortunes that overcame him in late years can dim the fame due him as builder of the utility system that bore his name, or, wipe out the debt that the industry owes him for pioneering developments. Without his active support and vision many technical advances would have been delayed for years and without his capable development of the holding company, thousands of square miles of the nation would yet be without electric service.

He had a magnetic personality and remarkable executive and financial ability, yet he liked to consider himself a utility operator with particular pride in the Commonwealth Edison Co. He was not an engineer. Born in London, Nov. 11, 1859, he went to work at 14 as an office boy and at 21 came to this country as secretary to Thomas A. Edison on the recommendation of his employer, the English representative of the inventor.

By 1889 he was vice president of the Edison General Electric Co. and in 1892 came to Chicago to head the new Chicago Edison Co. In 1907 all the Chicago electric companies were coördinated in the Commonwealth Edison Co. and he turned his attention to forming the Public Service Co. of Northern Illinois from properties acquired in the Chicago area. In 1912 he went farther afield and formed the Middle West Utilities which, starting in Canada, spread over the major portion of the United States. Insull interests also took over the Peoples Gas, Light & Coke Co., the elevated lines and several interurban electric lines which were large users of power. Much of the financing was accomplished by holding companies which finally headed up to the Insull Utility Investments and Corporation Securities. These first showed signs of toppling and are still involved in court action.

Insull plants were milestones on the road to the Power Age. Fisk, in 1903 as the first turbine station is perhaps the most famous, but Crawford Ave., with reheat and 50,000-kw. turbines, Powerton in the coal fields and one of the first really low heat rate stations, State Line with its 208,000-kw. turbine, South Amboy with its open heaters and Bremo with high single pass boilers and diphenyl heaters are but a few of the more spectacular technical advances which assure Mr. Insull a permanent niche in the industry's hall of fame.

George E. Emmons

GEORGE E. EMMONS, 80, formerly manager of the Schenectady Works of the General Electric Co., and later vice-president in charge of manufacturing for the company, died in Pasadena, California, July 1. Burial was at Pasadena July 6.

Mr. Emmons who devoted more than a quarter century directing the development of one of the world's biggest electrical plants as general manager of the Schenectady works, was born in Westchester, Conn., September 9, 1857. After 1886 he was continuously employed by the Thomson-Houston Electric Co. and the General Electric Co. until his retirement in 1924.

For the Engineer's Library

Any Catalogs that you wish will be gladly sent. Write Power Plant Engineering.

Prime Movers

Turbines — Power Impulse Turbine by Smith is the subject of a 32-page Bulletin 138 which gives a complete discussion of the subject and the manufacturer's contribution to the industry. S. Morgan Smith Co., York, Pa.

Radial flow surface condensers are described in a 24-page illustrated booklet. The basic principles, construction and operation are studied in this booklet. Auxiliaries, such as circulating and condensate pumps, steam jet ejectors, atmospheric relief valves, expansion joints, steam and electric pump drives, which assure additional efficiency and reliability, are also discussed. Three types of pumps decribed and illustrated are the impeller type, suitable for all condenser applications, but primarily used where a high section lift or high pumping head is specified; the propeller type, suitable where a moderate or large quantity of water at a relatively low pumping head is required; the axial type pump, for installation requiring a moderate pumping head and suction lift. Charts useful for calculating size of condenser and amount of circulating water required for a given duty, and also for approximating the performance of a given condenser with ¾, ⅞ or 1 in. O. D. tubes are shown. Copies may be secured from Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Electrical Equipment

Motors—Bulletin GEA 2026A contains information on the operating characteristics, construction feature and application of the G-E brakemotor. Bulletin GEA 1724A describes the construction and explains the operation of the complete line of G-E controllers for synchronous motors. General Electric Co., Schenectady, N. Y.

Motor and Switchgear — Bulletin 1165 A illustrates and describes the latest design and characteristics of bracket bearing type synchronous motors. Bulletin 1145B entitled Metal-Clad Switchgear deals with horizontal drawout metal-clad oil circuit breaker equipment for power stations, substations and general industrial purposes. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Why C.S.P. Transformers for Rural Service is the title of a 12-page illustrated booklet which describes the features of these transformers. They are completely self-protected against lightning, short circuits, and burnouts from overloads. Low installation cost and maintenance are provided because of no crossarms, fewer wiring connections and leak-proof tank. Illustrations include pictures of C.S.P. transformers, low-voltage bushings, cutaway view of "De-ion" Gap, circuit breaker, and circuit breaker with reset handle shown on the outside. Copies may be secured from Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

High Voltage Switchgear By I-T-E is the subject of Bulletin 638 which announces the extension of the company's line of air break switchgear to include circuit breakers for service on 2500-500-v. circuits. I-T-E Circuit Breaker Co., Philadelphia, Pa.

Boiler Accessories

Tube Cleaners—Cesco Boiler tube cleaners, air and water driven, are completely illustrated and described in a new 20-page catalog which has just been issued by the Chicago Engineer Supply Co., 116 W. Illinois St., Chicago, Ill.

Boiler Control—A new 4-page bulletin, 9766, describes the double purpose low water cut off, the McDonnell electric water valve and pressure limit control. It gives a description of each piece of equipment and uses of each, either alone or in combination with the other. McDonnell & Miller, Wrigley Bldg., Chicago, Ill.

Controlling Boiler Water Level on Combined Utility and Sugar Plant Load is the title of a new publication, Bulletin 413, which is fundamentally a description of the new plant of the Fort Bend Utilities Co. at Sugarland, Texas, and was prepared by J. H. Dunlap, plant superintendent. Northern Equipment Co., Erie, Pa.

A Story of Machines and Men is a four-page folder in color showing the part played by Hagan combustion control in modern boiler plants. Hagan Corp., Pittsburgh, Pa.

Piping

How to Join and Repair Pipe the Quick, Easy, Permanent Way—A 12-page booklet under this title gives operating men helpful information on how to construct and maintain pipe lines. Dresser Pipe Couplings for the joining of new lines and Dresser Repair Clamps and Repair Sleeves for the repair of old lines are fully described. S. R. Dresser Mfg. Co., Bradford, Pa.

Resistoflex, a new flexible tubing entirely impervious to oils and organic solvents is illustrated and described in a new folder issued by the Resistoflex Corp., 370 Lexington Ave., New York, N. Y.

Checking Up on Check Valves—An eight-page, two-color booklet under this title covers the whole check valve field in word, picture and diagram. The two basic types of check valves are described, their various applications are discussed, ten "Do's and Don'ts" are listed and two entire pages are devoted to cross-section views in what is called a Handy Reference Guide to Crane Check Valves. Crane Co., 836 South Michigan Ave., Chicago, Ill.

Welding

Welded Outlets for Piping—A new four-page bulletin No. WT28 has just been issued describing Bonney Weld-Olets and ThredOlets, the welded outlets for piping. In addition to the description of these drop-forged welding fittings used for making branch pipe outlets by welding, without any cutting, threading or fitting of the main pipe, the many additional advantages of the fittings are briefly described. A graphic illustration of the economies that can be effected through the use of WeldOlets and ThredOlets is also given, as well as complete tables of sizes in which they are available from stock, dimensions, weights and list prices. Numerous illustrations show the many types of installations on which they have been used economically and their ease of installation. Copies of the bulletin will gladly be sent on request to Bonney Forge & Tool Works, Allentown, Pa.

Welding Electrodes—Bulletin R-5 gives complete and specialized information and data on each of the many Smootharc welding electrodes. A modern manual of welding electrode information, this bulletin includes spar tests, procedure sheets and many other informative suggestions to make it a valuable reference book for all welder users and operators. Its information is applicable whether the job is welding Man-Ten steel, Chrome steel, stainless steel, manganese steel or nickel steel, and in overhead, downhand or poor fit positions. Copies may be obtained by writing the Harnischfeger Corp., 440 W. National Ave., Milwaukee, Wis.

Materials

Chromium Chemicals as Corrosion Inhibitors is the subject of discussion in an 8-page pocket size booklet issued by the Mutual Chemical Co. of America, 270 Madison Ave., New York, N. Y.

Flextite—A new product, a plaster coat waterproofing for stopping leaks is described in a new folder just issued by Flexrock Co., 800 N. Delaware Ave., Philadelphia, Pa.

Paint—A catalog devoted to the better maintenance of metal, concrete, wood, glass and composition surfaces describes 22 different kinds of paint and application of each. Also included in the catalog is a color chart showing 10 different colors. The Skybryte Co., Cleveland, Ohio.

Insulag, a strong, non-shrinking refractory lagging for interface temperatures up to 2200 deg. F., or directly exposed to 2000 deg. F., which can be applied on hot surfaces, is described and illustrated in an eight-page bulletin which includes two full page charts, to determine thickness of Insulag required for hot face temperatures and ascertaining efficiency of thicknesses of Insulag. Quigley Co., Inc., 56 West 45th Street, New York, N. Y.

Power Plant Construction News

Calif., Burbank—Lockheed Aircraft Corporation, Victory Place, plans installation of new addition to airplane-manufacturing plant, 120x320 ft., to be used primarily for assembling operations. Erection scheduled to begin early in August. Entire project will cost about $140,000. Other plant additions are planned at later date.

Calif., Los Angeles—Miller Malting Co., Hollywood Gurantee Building, plans installation of power equipment in new malt products plant at 6500 Malt Street, Florence district. Work is scheduled to begin at early date. Cost close to $170,000. Edward Wilkes, Mutual Building, Kansas City, Mo., is architect and engineer.

Calif., Los Angeles—Pathe Film Corporation, 30 Rockefeller Plaza, New York, N. Y., plans installation of electric power equipment in new motion picture film plant at Hollywood, Los Angeles, consisting of several large units. Entire project will cost close to $500,000.

Colo., Denver—Bureau of Reclamation, Denver, has secured an appropriation of $1,000,000 for Elephant Butte hydroelectric generating plant, Rio Grande project, New Mexico-Texas. Plans will be drawn at early date.

Fla., Jacksonville—City Commission has secured Federal grant of $1,127,000 to be used for extensions and improvements in municipal electric power plant, including installation of a 25,000-kw. turbo-generator unit and accessories, boiler, pumps and complete auxiliary equipment. Entire project will cost $2,500,000, remainder of fund to be provided by city.

Fla., Tampa—Lykes Brothers, Inc., Palm River, Tampa, plans installation of power equipment in new one-story addition 150x200 ft., to meat-packing plant, for which superstructure will begin soon. Entire project will cost about $100,000. H. Peter Henschien, 59 East Van Buren Street, Chicago, Ill., is architect and engineer.

Ill., Danville—Peabody Coal Co., 231 South LaSalle Street, Chicago, Ill., plans early construction of new mechanical coal washing and cleaning plant at mining properties near Danville. Cost estimated over $500,000. Company engineering department will be in charge.

Ind., Terre Haute—Bureau of Prisons, Department of Justice, Washington, D. C., plans power plant at new Federal prison on 1200-acre tract of land recently acquired near Terre Haute. Also will build pumping station and other utilities. Entire project will cost $3,000,000. Appropriation has been authorized. Proposed to ask bids at early date.

Iowa, Muscatine—First Iowa Hydro-Electric Coöperative, Inc., 210 Walnut Street, Muscatine, plans hydroelectric generating plant on Cedar River, Muscatine County, with power dam, power station, switching station, transmission and distributing lines. Cost about $3,500,000. Financing is being arranged through Federal aid. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Kan., Larned—City Council plans expansion and improvements in municipal electric power plant, with installation of additional equipment. Cost estimated about $100,000. Financing will be arranged through Federal aid. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

Ky., Owensboro—City Council plans extensions and improvements in municipal electric light and power plant, including installation of additional equipment. Also proposes extensions in water plant and system. Entire project will cost close to $2,300,000. Financing will be arranged through Federal aid. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

Mich., Milan—Bureau of Prisons, Department of Justice, Washington, D. C., plans new boiler plant at Federal prison at Milan. An appropriation of $90,000 has been authorized. Proposed to begin work soon.

Mich., Northville—Michigan Wood Products Co., Plymouth Road, plans installation of power equipment in connection with proposed rebuilding of wood specialty manufacturing plant, recently destroyed by fire. Loss estimated over $75,000.

Mich., South Rockwood—Huron River Silica Corporation, Dime Bank Building, Detroit, Mich., plans installation of electric power equipment in new silica sand-mining and processing plant at company properties at South Rockwood. A power house is planned Company is completing financing through sale of stock totaling close to $560,000, majority of fund to be used for new plant noted.

Mo., St. Louis—American Refrigerator Transit Co., 210 North Thirteenth Street, plans installation of electric power equipment in new car repair shops on local site at Main and Barton Streets, comprising several one-story units. Entire project will cost over $175,000. A. L. Becker, architect for Missouri-Pacific Railroad Co., Missouri-Pacific Building, St. Louis, is architect.

Mo., St. Louis—Cole Chemical Co., Inc., 3721-27 Laclede Avenue, plans installation of electric power equipment in new additions to plant. Cost estimated close to $100,000. Hugo L. Graf, 2825 Oliver Street, is architect.

Neb., Blair—City Council plans expansion and improvements in municipal electric power plant, with installation of additional equipment. Cost about $117,000, of which $62,650 will be arranged through Federal grant. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

Neb., Schuyler—City Council plans extensions and improvements in municipal electric power plant, including installation of a 1000-kw. turbo-generator unit and accessories, switchboard and miscellaneous equipment. Cost estimated close to $110,000. Financing will be arranged through Federal aid. Black & Veatch, 3706 Broadway, Kansas City, Mo., are consulting engineers.

N. J., Hoboken—Eisen Brothers Parlor Frame Co., Inc., Willow Avenue and Sixteenth Street, plans installation of electric power equipment in two-story addition to furniture factory, 50x 300 ft. Entire project will cost over $70,000, with machinery.

N. J., Trenton—Joseph Stokes Rubber Co., Taylor Avenue, has filed plans for new steam power house at rubber mill, and will proceed with work at once. Cost estimated close to $30,000 with boiler units and auxiliary equipment.

N. J., Wrightstown—Constructing Quartermaster, Camp Dix, near Wrightstown, will build a new power plant at local Government camp. Work will be carried out in connection with expansion and improvements in properties to cost $935,000, in which amount appropriation has been arranged, to include new buildings, barracks, shops, oil and gasoline storage facilities, and other work. Program is scheduled to begin soon.

N. Y., West Point—Constructing Quartermaster, U. S. Military Academy, West Point, will receive bids until Aug. 9 for furnishing and installing a 1000-kw. turbo-generator unit and accessory equipment in local power plant, as per plans and specifications on file.

N. C., Farmville—Town Council will make extensions and improvements in municipal electric light and power plant, including installation of a Diesel engine-generator unit and auxiliary equipment. Fund of $177,275 has been arranged for this and improvements in water and sewage system, of which $79,774 will be secured through Federal grant.

Okla., Fairview—Common Council plans extensions and improvements in municipal electric power plant, including installation of additional equipment. Cost about $60,000. Financing is being arranged through Federal aid.

Okla., Purcell—Common Council is considering extensions and improvements in municipal electric power plant, including installation of additional equipment. Also for additions in water plant and system. Entire project will cost about $150,000. Financing in part is being arranged through Federal aid.

R. I., Newport—Bureau of Yards and Docks, Navy Department, Washington, D. C., will have plans soon for extensions and improvements in power plant at naval torpedo station, Newport, including installation of additional equipment. Work is scheduled to begin soon. Appropriation of $300,000 has been authorized.

Texas, Llano—Municipal Council has authorized surveys and estimates of cost for new municipal electric light and power plant. Financing will be arranged through Federal aid. Joseph E. Ward, Harvey-Snider Building, Wichita Falls, Texas, is consulting engineer.

Wash., Tacoma—J. E. Berkheimer Mfg. Co., 2928 South M Street, plans installation of electric power equipment in connection with rebuilding of prepared roofing-manufacturing plant, recently destroyed by fire. Loss estimated at close to $100,000. Reconstruction will cost approximately a like sum.